THE PRODUCTION OF SCIENTIFIC KNOWLEDGE IN ONTARIO UNIVERSITIES:

An Overview of Problems

[Report and studies]

Ontario

Commission on Post-Secondary Education in Ontario

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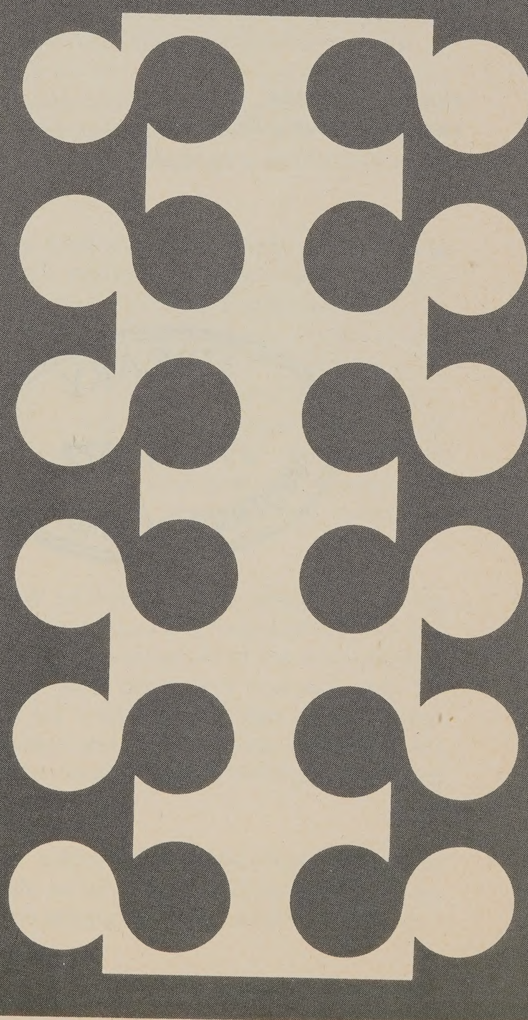

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The Production of Scientific Knowledge in Ontario Universities: An Overview of Problems

Editorial Foreword

The Commission on Post-Secondary Education in Ontario was instructed by its terms of reference to study and make recommendations on "the type, nature and role of the institutions required to meet the educational needs of the Province with particular reference to existing institutions and their ability to meet present and future demands . . ." and "the facilities required to meet needs, including specialized facilities such as research laboratories, libraries, computer facilities, etc."

Because our universities have traditionally had research as one of their principal functions, the provision and maintenance of research facilities is fundamental to the operation of such institutions. Equally important is the provision of the time and money needed by university faculty to carry out the research activities which, along with teaching, have been part of their normal duties. But today, changes in the circumstances surrounding post-secondary education have created a number of issues relating to this research function of post-secondary educational institutions. One of the most general of these issues was raised by the Commission in its ***Statement of Issues***: "Is research—given its present scope and definition—really as essential a part of all university and college education as it was a few years ago—and is still proclaimed to be?" And, more specifically, there are complex issues of funding, setting priorities, and establishing appropriate administrative structures for such research activities as are to be carried on in post-secondary institutions in the future.

One of the Commission's principal tasks has been to identify and to organize these numerous and complex issues relating to the research function of post-secondary institutions in Ontario in such a way as to permit a rational examination of them. To this end two separate background studies were commissioned on the topic: one, "Universities and Colleges in Ontario and their Role in Research and the Production of Knowledge" was prepared by Dr. E. L. Holmes, Associate Dean of Engineering at the University of Waterloo, Waterloo, Ontario. The other, published in the present volume, is the work of Anthony H. Smith, Assistant Professor of Sociology at the University of Toronto. Professor Smith received his undergraduate education at Leicester University in England and, at the time of preparing this study, was completing a Ph.D. degree at Princeton University.

The main objectives of the study reported on here were to analyze both the consequences of university organization for the conduct and nature of research and the consequences of the funding of research for the structure of the institutions in which it takes place. The severe time and other constraints imposed upon the author necessitated certain limitations in his treatment of these topics. These limitations are described in the author's preface, and should be kept in mind by the reader, especially when interpreting the inferences drawn from the study in Chapter 7, "Overview: The Possible Directions of Change."

In particular it should be noted that the author has not essentially dealt with research in the humanities or with what might be termed contemplative scholarship, since his study is duly concerned with "the production of scientific knowledge".

Consequently, he does not consider the maintenance and development of an intellectual tradition in Ontario, which to a notable extent has been a function of the province's universities. The development of that tradition has certainly involved its continual dissemination through teaching, but it has also been shaped to a high degree through the inquiries, reflections and creative writings of scholars in Ontario universities. The question of the "usefulness" of such intellectual labours involves value judgements that are hard to measure. There is also the problem of time-span in the making of any assessment: an intellectual product may seem of little use in the scholar's own time, yet turn out to be of great impact and importance in a later day. In general, one must simply assert that man has a rooted belief that knowledge is more useful than lack of it, and that the attempts to add to the awareness and understanding of man's experience and main concerns is in itself a most characteristic human activity, carried on in every civilization of the past and present. And thus intellectual activity may include scientific research, but can comprise a great many other things besides.

Accordingly, there is a sizeable area of scholarly work not directly dealt with in Professor Smith's study which must be weighed in the balance for any comprehensive judgement of the research function in post-secondary education. The writings of an H. A. Innis on economic history, of a Northrop Frye on literature are, for example, outstanding achievements in the Ontario intellectual tradition which have had significance and influence far beyond Ontario, however difficult it would be to rate them in terms of "useful" inquiry deserving public support. Fortunately, perhaps, such endeavours and accomplishments generally cost far less to support than do scientific ventures to secure more immediately relevant information. Yet it is necessary to observe that, apart from money, they need time; and time for contemplation and creation within any university system costs money also. In sum, then, it bears emphasizing that while the present study by Professor Smith deals with research problems that are generally the most obvious and expensive for the people of this province, it by no means seeks to cover the whole extent of the problems of scholarship that are of vital and integral importance to the field of post-secondary education in Ontario.

This study was submitted to the Commission in October, 1971. Its opinions and conclusions are solely those of the author, and its publication does not necessarily mean that all the opinions and conclusions contained therein are endorsed by the Commission.

The Production of Scientific Knowledge in Ontario Universities: An Overview of Problems

A report prepared for:

The Commission on Post-Secondary
Education in Ontario

Anthony H. Smith

Preface

The analysis in this report is based entirely on data which were readily accessible. Given this, and given the very short period of time allowed for completion of this project, a number of problems should be pointed out. First, the data are less than adequate in innumerable places. Reliance on secondary sources and use of information from analyses with purposes markedly different from the one pursued here inevitably means that much of the data are unsatisfactory. Second, it was not possible in the time permitted to pursue the question of "comparability" of data drawn from different sources as thoroughly as would have been desirable. Third, the information used is selective and not comprehensive; some might suggest even "partial." Most information is used as illustration of analysis rather than as systematic test of ideas. A more complete test of some of the central ideas of this report would therefore be useful. Fourth, the analysis has not been pursued as far as might be possible.

Because of all these factors, there are certain areas of the report which are weaker than others. The primary focus of the report is on research in the natural sciences exclusive of medical research. Material concerning the latter is introduced for comparative purposes, as is infor-

mation on the humanities. Admittedly, however, the treatment of these two areas is fragmentary. Social sciences receive more systematic attention, but again, coverage is less comprehensive than for the natural sciences. It is important to note that statements in the concluding sections of the report were developed primarily in relation to the natural sciences. This does not mean that they are irrelevant to other areas--indeed, much of the analysis,with the exception of the comments on "applied research," is relevant to both social science and medicine. At the same time, application of conclusions in these areas must be made much more cautiously.

Finally, I am grateful to a number of people who provided information and assistance in the preparation of this report. Personnel of the various Research Councils provided valuable information. Research administrators at various universities supplied analyses and information on the organization of university research, and many ideas obtained through interviews with them are incorporated in the text. Bill Bryant, my research assistant, contributed a great deal of hard work. My colleagues, Jos Lennards and Jeff Reitz, read and commented on earlier versions of this report, and their suggestions were incorporated in a revised version. Responsibility for the finished product, however, rests with the author alone.

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I. Introduction

A. Growth Rates in Science

In 1962 Price[1] noted that science had grown exponentially in preceding decades. Pointing out that such growth would within a century result in more scientists than population, and would need more money than available gross national products, he went on to suggest that the continuance of such growth rates was impossible: "All the apparently exponential laws of growth must ultimately be logistic, and this implies a period of crisis extending on either side of the date of midpoint for about a generation."[2]

Price's analysis does not make clear the point at which a given country reaches the inflection point on this supposed logistic curve, nor is it clear whether this point is the same for different countries. If science spending is measured as a proportion of GNP, Canada's 1.4 per cent on research and development in 1967 was low compared with other industrialized nations, and was only half the percentage figure for the U.S.[3] Nevertheless, in Canada, as elsewhere, the subject of the nature and utility of investment in knowledge-production is generating increasing debate. Decisions will likely be taken in the near future which will shape Canada's knowledge-production

efforts for a considerable time to come. Whether the end point of this debate will fulfil Price's more gloomy predictions--a shrinking of the science sector--only time will tell. Certainly some slowing in growth rates must eventually occur.

B. Growth Rates in the Cost of Higher Education

There are additional reasons for believing that debate over the role of research will be intensified in its effect on higher education. Here, a parallel crisis, already far advanced in the U.S., is developing. As Bowen[4] has pointed out, education is one of the few remaining sectors of the economy which is labour intensive. The implication is that education tends not to experience the worker-productivity increases that improved technology creates in industry. In education, technological change not only makes old tasks cheaper, but also, and particularly in the area of research, creates new, more expensive ones. For example computers made feasible research which was previously limited by the complexity of the required data processing. Bowen explains this problem in the following terms:

> Let us imagine an economy divided into two sectors, one in which productivity is rising, and another in which it is constant, the first producing automobiles, and the second, "education" (defined as some amalgam of students and knowledge). Let us suppose that in automobile production output per man-hour increases at an

> annual rate of 4 per cent compared with a zero rate of increase in the education industry. Now let us assume that money wages in the automobile industry go up at the same rate as productivity in that industry. This means that each year the typical auto worker's wage goes up by 4 per cent but since his output increases by exactly the same percentage, the labour costs of manufacturing a car will be unchanged. This process can continue indefinitely with auto workers earning more and more each year, with costs per car remaining stationary, and with no rise in automobile prices necessary to maintain company profits.
>
> But what about the education industry?...If the salary of the typical faculty member... increase(s) at an annual rate of 4 per cent, so that his living standard improves along with the living standard of the auto worker, but if output per man-hour in the education industry remains constant, it follows that the labour cost per unit of educational output must also rise 4 per cent per year. <u>And there is nothing in the nature of the situation to prevent educational costs per unit of product from rising indefinitely at a compound rate of this sort.</u>[5]

Put more bluntly, this analysis suggests that, even without further university expansion in Ontario, the cost of higher education is likely to rise at a faster rate than costs generally.

C. <u>The Contents of this Report</u>

This report analyses the structure of research performance and financing of research for Ontario universities. Three tasks are involved; the description of research financing in Canada and Ontario; an examination of the effects of university characteristics on research performance; and a

look at the impact of research on universities. Completion of this task requires not only examination of available information on Ontario, but also the introduction of some of the general ideas developed by sociologists in the analysis of "science."

To these ends, the report is organized as follows: Chapter Two summarizes available information on the sources and receipt of research money by Ontario universities. This chapter is primarily descriptive. Chapter Three overviews the major concerns of the sociology of science and provides some critical general comments which are also relevant to examination of the Ontario case. Chapter Four uses the ideas set out in Chapter Three to develop a structural analysis of research orientations. This important section develops two themes. First, the "basic" orientations of research are viewed as a consequence of structural features of universities and characteristics of the system of funding. Second, characteristics associated with the organization of research in Ontario universities are examined in an attempt to provide comments on the "effectiveness" of research. Chapter Five looks at the impact of research on the universities. Particular focus is made on the financial strains generated by research, and on hypothesizing about the effect of research on teaching.

The concern of Chapter Six is with the pattern of distribution of research funds and Ph.D. production over the Ontario system as a whole. Since this feature of university organization is likely to be of increasing importance, Chapter Six provides some additional background ideas for Chapter Seven, where analysis is made of the kinds of changes necessary to reduce the problems looked at in earlier chapters.

Notes - Chapter I

1. Derek J. de Solla Price, Little Science, Big Science (New York, Columbia University Press, 1963), 1-32.
2. Ibid., 30.
3. A Science Policy for Canada: Report of the Senate Committee on Science Policy, Vol. 1, A Critical Review: Past and Present (Ottawa, Queen's Printer, 1970), Table 2, 122.
4. William G. Bowen, The Economics of the Major Private Universities (Berkeley, Carnegie Commission on Higher Education, 1968), 12-16.
5. Ibid., 14-15.

II. Patterns of University Research Support: Canada and Ontario

A. Ontario's Position in Canadian University Research

Exponential rises in science spending have been the pattern in Canada as in other nations. Total support of scientific research in Canada has risen markedly over the past decade from $304.6 million in 1957 to $895.5 million in 1967. Not only has the absolute amount of money received by the university sector increased, but universities have also increased their share relative to the other two major research sectors, industry and government. (See Table II.1) In 1957 universities received only 8.5 per cent of total Canadian research and development expenditures. By 1967 their share had risen to over 25 per cent. Thus universities have been important beneficiaries of increasing science spending.

Ontario universities receive a substantial portion of this research income. As Table II.2 shows, in 1967-68 44 per cent of the total research income of 49 Canadian universities and colleges was received by Ontario universities. Furthermore, Ontario has achieved pre-eminence in research fairly recently. Research money was much more equitably distributed in 1956-57, with Ontario receiving only 36 per cent of the total, an amount

Table II.1

Distribution of National Government and Non-Government R & D Expenditures by Sector of Performance in Canada, 1957-67

Year	Government	Industry	Universities	Other	Total
		Millions of Dollars			
1957	134.9	140.1	25.8	3.8	304.6
1958	141.0	150.5	33.8	3.8	329.1
1959	151.2	110.3	43.3	4.3	309.2
1960	172.4	92.7	51.8	4.8	321.7
1961	199.0	130.5	57.8	5.5	392.8
1962	187.9	140.3	69.6	6.1	403.9
1963	187.7	184.3	85.2	7.2	464.4
1964	207.5	237.9	108.4	7.6	561.4
1965	234.6	287.9	146.2	7.9	676.6
1966	266.6	303.2	189.4	10.0	769.2
1967	318.9	337.8	238.8		895.5
		Percentages			
1957	44.3	46.0	8.5	1.2	100.0
1958	42.8	45.7	10.3	1.2	100.0
1959	48.9	35.7	14.0	1.4	100.0
1960	53.6	28.8	16.1	1.5	100.0
1961	50.7	33.2	14.7	1.4	100.0
1962	46.5	34.7	17.2	1.5	100.0
1963	40.4	39.7	18.3	1.6	100.0
1964	37.0	42.4	19.3	1.4	100.0
1965	34.7	42.6	21.6	1.2	100.0
1966	34.7	39.4	24.6	1.3	100.00
1967	35.6	37.7	26.7		100.00

Source: A Science Policy for Canada: Report of the Senate Special Committee on Science Policy (Ottawa, Queen's Printer 1970) Table 4, 127.

Table II.2

Research Incomes[a] of 49 Universities and Colleges[b] 1956-57 to 1967-68

	Atlantic Provinces (11 univ.)		Ontario (18 univ.[c])		Quebec (9 univ.)		Prairie Provinces (7 univ.)		B.C. (4 univ.)		TOTAL (49 univ.)
	$000's	%Total	$000's	%Total	$000's	%Total	$000's	%Total	$000's	%Total	$000's
1956-57	252	3	3,623	36	3,780	37	2,417[d]	24	-		10,072
1957-58	253	2	3,997	36	3,965	36	2,924[d]	26	-		11,139
1958-59	499	3	4,824	34	4,919	34	4,197[d]	29	-		14,439
1959-60	639	3	6,301	34	5,644	30	3,676	20	2,066	11	18,325
1960-61	797	4	7,050	34	6,444	31	4,028	19	2,588	12	20,907
1961-62	967	4	9,296	36	8,141	32	4,860	19	2,867	11	26,130
1962-63	1,156	4	10,441	35	8,839	30	5,951	20	3,262	11	29,649
1963-64	1,610	5	11,957	34	10,601	30	7,789	22	3,609	10	35,564
1964-65	1,903	4	19,561	41	12,723	27	8,488	18	4,550	10	47,225
1965-66	2,426	4	26,052	43	16,472	27	10,253	17	5,709	9	60,912
1966-67	3,456	4	33,869	43	20,731	26	14,087	18	7,462	9	79,604
1967-68	4,893	5	44,918	44	24,177	23	19,310	19	9,860	10	103,158

Notes: (a) In Hettich these figures appear as "expenditures." Hettich's data source is, however, DBS-CAUBO returns, where expenditure is equated by reporting universities with income.

(b) These 49 universities and colleges accounted for 85 per cent of total enrolment in Canadian universities in 1967-68.

(c) Includes Waterloo Lutheran, excludes OISE. The colleges within the University of Toronto are each counted separately.

(d) Includes British Columbia for these years.

SOURCE: Compiled from Hettich, Walter, Expenditures, Output and Productivity in Canadian Education. Special Study No. 14, Economic Council of Canada (Ottawa, Information Canada, 1971), Table 3-1, 18, Table E8, 101

slightly less than that for Quebec. Quebec ended the period with just over half as much research money as Ontario. Other regions approximately maintained their shares of the total so that Ontario's gain occurred largely at the expense of Quebec.

Part of the growth in Ontario universities' research income is explained by simple growth in size. At the same time, Ontario still receives a disproportionate amount of money in relation to the size of university enrolment. In 1967-68 Ontario had 31 per cent of students enrolled[1] in the 49 universities referred to above. That year these same universities received 43 per cent of the total research income. The percentage of total research income for Ontario is, however, much closer to the percentage of total graduate students (40 per cent).[2]

B. The Sources of Research Income

In 1967-68, 68 per cent of the research income of Canadian universities was from the federal government (see Table II.3).

Table II.3

Assisted Research Funds of Canadian Universities
by Sources of Funds, 1961-62 - 1967-68

Source	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68
	($000,000)						
Fed.Govt.	16.8	18.7	22.7	27.3	36.6	52.1	71.2
Prov.Govt.	1.1	1.4	1.7	7.1	9.4	11.8	15.3
Corporations	1.1	1.3	2.0	2.6	2.7	2.7	2.8
Foundations	4.0	4.6	4.9	4.7	5.7	7.0	8.3
Other	3.5	4.7	5.5	5.9	7.1	7.1	6.5
Total	26.5	30.7	36.8	47.6	61.5	80.7	104.2

Source: Waines, W.J. Federal Support of Universities and Colleges of Canada. Financing Higher Education in Canada, No. 7 (Ottawa, Association of Universities and Colleges of Canada, 1970), Table IV 59.

In the period from 1958-59 to 1967-68 provincial governments have increased their percentage of total research funds. At the same time, these overall Canadian data are somewhat misleading since in 1967-68 over two-thirds of this amount was provided by the Ontario government ($10.7 million out of a total of $15.3 million).[3] This figure was almost five times larger than the next largest provincial government contribution, which was for Quebec ($2.3 million).[4] The large provincial expenditure in Ontario also affects the distribution of funds between sources. Although Ontario in 1967-68 had a disproportionate share of money from the federal government, the Ontario university system receives a higher proportion of its money from provincial

sources (24 per cent) than do university systems in other provinces.[5]

This study focuses primarily on federal money. There are a number of reasons for this. As suggested above, the federal sector is the main source of money. Moreover, within the federal sector, the Councils--the National Research Council, the Medical Research Council, and the Canada Council play a major role. While we do not have data which analyses sources of funding by the discipline groupings within which the Councils operate, it is nevertheless clear that the respective Councils dominate their areas. Thus, while the Canada Council's operations are small, as Table II.4 indicates, relative to NRC and MRC, it is the most important source of funds for social science and humanities.

All of the remaining sources of money are diverse. That is, while the money may be grouped into various categories (for example,those in Table II.3 above, or those used by the University of Toronto--"councils," "other government agencies," "U.S. firms," "Canadian firms," "U.S. charitable agencies," "Canadian charitable agencies"[6]) these are not meaningful for analysing effects on universities. The categories do not represent groupings of funding agencies with similar research

Table II.4

Research Councils' Support of Research in Canadian Universities 1960-61 to 1969-70 - Millions of Dollars. (Scholarships, Fellowships, Research Grants, etc.)[a]

	60-61	61-62	62-63	63-64	64-65	65-66	66-67	67-68	68-69	69-70
National Research Council	7.2	8.9	10.7	12.8	17.4	22.1	34.6	45.8	59.3	65.0
Medical Research Council	2.2	3.0	4.3	5.1	6.9	9.2	15.4	20.5	27.0	31.0
Canada	1.1	1.1	1.3	1.3	1.4	3.1	5.8	11.6	16.6	18.4
Total	10.5	13.0	16.3	19.2	25.7	34.4	55.8	77.9	102.9	114.4

Note a. In most other places in this report figures for research are for assisted research support only.

Source: Waines, "Federal Support of Universities and Colleges in Canada." Table V. p. 63.

funding policies. Thus, for example, in the past, agencies within given categories have not had similar policies with respect to "overhead" (indirect costs for building maintenance, light, etc.) or the accounting of direct costs (e.g. faculty time). Similarly there appears to be much variation in non-Council agency use of "grants" as opposed to "contracts," and even, it has been suggested, sometimes little distinction between the two.[7] In the absence of coherent policies among non-Council agencies, and until recently with no strong push from the universities to change this, funding from these agencies seems to have shown a tendency to follow Council policy. Academics who solicit money have had little incentive to attempt to obtain categories of cost not covered, and their expectations about what to solicit are set by the activities of the major funders, the Councils. Universities are unlikely to wish to discriminate against agencies in order to increase payment of costs not covered since this would imply discrimination against researchers dependent on non-Council funds. Universities do seem now to be attempting to establish a united front in asking costs from non-Council federal agencies.

In addition, single sources outside the Councils account for only small percentages of the total research

income of universities. For example, while the Defense Research Board spent $2,821,340[8] on university research in 1967-68, and National Health and Welfare $7,164,000,[9] these figures represented only 2.7 per cent and 7.6 per cent respectively of total university research income. It is unlikely that any non-federal agencies exceed these examples in Canada as a whole though some of the provincial agencies (particularly the Department of University Affairs and the Ontario Department of Health) may provide larger amounts in Ontario than the large non-Council federal agencies.

Unfortunately we are not able to provide analyses of the activities of non-Council agencies. This could be accomplished by one of two methods. One would be to obtain detailed information on sources of funding and funding policies for these sources from the Ontario universities. The other would involve approaching funding agencies themselves for data on research funded in universities in Ontario. Either one of these tasks would require a major research effort, and this was not possible within the time available. For example the University of Toronto lists 149 organizations or individuals as contributors of research money to the university in 1969-70 alone. Table II.5 summarizes this information.

Table II.5

University of Toronto, Number of Agencies Providing Funds in Ranges Specified - 1969-70.

Size of Award ($000.)		No. of Agencies
$500 thousand and above		4*
$400-499		1**
$300-399		2***
$200-299		8
$100-199		6
$50-99		13
$10-49		46
$under 10		69
Total $value of awards $18,630,013	Total Number	149

*these were NRC $6,458,760, MRC $4,734,747, Canada Council $711,281, Dept. of National Health and Welfare $586,773.

**this was the Ontario Department of Health $483,205.

***these were Defence Research Board $342,250; Alcoholism and Drug Addiction Research Foundation $346,615. The third was a federal government agency the name of which is missing from the list.

Source: Data Supplied by University of Toronto, Office of Research Administration.

63.9 per cent of the University of Toronto's money was from the Councils. Only 21 agencies provided amounts greater than $100,000. The remaining agencies provided small amounts, 46 providing between $10,000-$49,000, and 69 agencies providing amounts under $10,000.

While we have available detailed breakdowns of sources of income only for the largest university, Toronto, it is possible to describe in more detail the non-Council federal income of Ontario universities. The MacDonald Report[10] gives data collected from these federal agencies on research funds provided by them to all Canadian universities in 1967-68. The relevant information for Ontario universities is shown in Appendix One at the end of this report. Again, it is clear that even for these relatively large scale funding agencies, the amounts given to individual universities by single agencies are small and unlikely to represent a large percentage of any university's total research income.

Given the complexity of summarizing this kind of data, beyond that available on federal sources, diversity of agencies, and relatively small amounts provided by single non-Council agencies, the main focus in this paper is on the Councils. The Councils are the most important funders, and their consistent funding policies have had a major impact on the direction of university research.

C. The Consumption of Research Money

The money received by the Ontario universities from the various agencies is not evenly distributed. As indicated in Table II.6, the University of Toronto in 1968-69 and 1969-70 received almost three times as much money as Western, its nearest competitor. In both years the four universities with the largest research incomes (Toronto, McMaster, Western and Queen's) received over 65 per cent of the total research income of the 14 universities, while inclusion of the next four brings this figure to over 90 per cent for both years.

A more comprehensive attempt to analyse the receipt of research income would require more detailed data. Ideally this would include information on (i) receipt of money by university, by department, (ii) number of faculty and faculty characteristics by university, by department, (iii) numbers of students both undergraduate and graduate by university and by department. Unfortunately detailed data of this type are not readily available.

The disproportionate amount of research money consumed by the four universities Toronto, McMaster, Queen's and Western is in part a reflection of the size of these universities and the distribution of faculty within them. Most research support is allocated to the physical

Table II.6

The Receipt of Research Income by Ontario Universities 1968-69, 1969-70.

1969-70

University	Amount ($000's)	% Total	Cumulative %
Toronto	18,254	35.5	35.5.
Western	6,222	12.1	47.6
McMaster	5,961	11.6	59.2
Queen's	5,160	10.0	69.2
Waterloo	4,182	8.1	77.3
Ottawa	2,990	5.8	83.1
Guelph	2,528	4.9	88.0
York	2,241	4.4	92.4
Carleton	1,664	3.2	95.6
Windsor	1,089	2.1	97.7
Trent	377	0.7	98.4
Brock	261	0.5	98.9
Lakehead	260	0.5	99.4
Laurentian	208	0.4	99.8[a]
TOTAL	51,397		

1968-69

University	Amount ($000's)	% Total	Cumulative %
Toronto	16,146	36.2	36.2
Western	5,821	13.1	49.3
McMaster	4,795	10.8	60.1
Queen's	4,866	11.0	71.1
Waterloo	3,702	8.3	79.4
Ottawa	2,709	6.1	85.5
Guelph	2,129	4.8	90.3
Carleton	1,439	3.2	93.5
York	1,330	3.0	96.5
Windsor	806	1.8	98.3
Trent	335	.8	99.1
Lakehead	170	.4	99.5
Brock	162	.4	99.9
Laurentian	136	.3	100.2[a]
TOTAL	44,546		

Note a: Figures do not add to 100 per cent because of rounding.

Source: DBS-CAUBO Report of Financial Statistics of Universities and Colleges.

sciences, so a university such as York which in 1969-70 had only 94 (20 per cent) out of a total of 460[11] of its faculty in pure and applied science, is unlikely to draw much research income. Similarly, while Toronto's research income in 1969-70 was over three times the income of Queen's, Toronto also had over three times the number of faculty in pure and applied science.[12]

Affecting the general size of a university's science faculty, and hence its research intensity, is the presence of relatively specialized "professional" schools of Engineering and Medicine. Both of these areas draw large amounts of research money. Tables II.7 and II.8 show the receipt of money in Engineering and Medicine respectively for 1968-9. It is worth noting that the four universities with the highest research incomes possess both a Medical School and an Engineering Faculty.

Table II.7

Funds Committed to Research as Grants in Aid-
Medical Schools of Ontario 1968-69[a]

University	Amount ($000)
Toronto	7,745
Western	2,250
Queen's	2,037
Ottawa	1,369
McMaster	1,059
TOTAL	14,461

[a]Survey was performed in period June-September 1969. Figures assumedly refer to year 1968-69.

Source: Specialized Manpower Production and Research Development in Ontario Faculties of Medicine 1969-75. (Toronto, Ontario Council of Deans of Medicine, 1970) Table II, p.9

Table II.8

Funds Committed to Research as Grants in Aid-Ontario Faculties of Engineering, 1968-69, 1969-70.

	Amount ($000's)	
University	1968-69	1969-70
Toronto	2,150	2,541
Waterloo	1,333	1,782
McMaster	774	1,153
Queen's	765	615
Western	517	391
Windsor	294	391
Guelph	210	210
Ottawa	209	261
Carleton	194	229
	6,446	7,573

Source: Ring of Iron: A Study of Engineering Education in Ontario. A Report to the Committee of Presidents of Ontario Universities. (Toronto, Committee of Presidents, 1970, Table 5.1, 24.

Notes - Chapter II

1. Walter Hettich, Expenditures Output and Productivity in Canadian Education. Special Study No. 14, Economic Council of Canada. (Ottawa, Information Canada, 1971), Table 4-1, 37, and Table E-13, 106.
2. Ibid.
3. Dominion Bureau of Statistics, Canadian Universities, Income and Expenditure, 1967-8, (DBS: 81-212) 38-39.
4. Ibid.
5. Ibid.
6. Statement of the University of Toronto to the Committee on University Affairs, Appendix B., "Research in the University" (Toronto, University of Toronto, 1970), 2.
7. See The Role of the Federal Government in Support of Research in Canadian Universities. Special Study No. 7, Science Council of Canada (Ottawa, Queen's Printer, 1969), 168-170.
8. Calculated from The Role of the Federal Government in Support of University Research, 259, and Waines, W.J., Federal Support of Higher Education in Canada. Financing Higher Education in Canada, No. 7 (Ottawa, Association of Universities and Colleges of Canada, 1970), 59.

9. Calculated from _The Role of the Federal Government in Support of University Research_, 296, and Waines, _Federal Support of Higher Education in Canada_, 59.
10. _The Role of the Federal Government in Support of University Research_, Appendix 1, 249-311.
11. Data on the distribution of faculty by disciplines is taken from recent data published by the Committee of Ontario Universities. The main focus of this data was citizenship by discipline group, by university.
12. Committee of Ontario Universities Citizenship Data.

III. The Production of Knowledge in its Structural Setting

In the next section of this report an attempt is made to provide some analysis of the inter-relationship between research support and the nature of research in Ontario universities. Important to the understanding of this are general ideas on the working of university disciplines, or what is referred to usually as the "structure of science."

A. The Sociology of Science: An Overview of Theory

The literature in the sociology of science has concentrated primarily on the conditions which promote growth of basic knowledge. Where "applied" or "mission-oriented" settings are considered, they have been viewed primarily from a perspective which looks for "strains" consequent upon the employment of scientists in settings (applied) for which their training (basic science) is asserted not to suit them.[1] In particular little attention has been paid to applied, university research.

This concern in the sociology of science for "basic knowledge" parallels the concerns of philosophers and historians of science. Philosophers of science have constructed a picture of science as a systematically interrelated set of ideas derived by processes of logical (mathematical) reasoning from general "laws." These ideas are empirically contingent and tested relative to data.[2]

Kuhn[3] has modified the conception of science presented by philosophers of science, by distinguishing between "normal science" and the occurrence of "revolutionary" theoretical changes. "Normal science" is the process of articulating the implications of a given theory and conforms to the processes which are the central concerns of philosophers and sociologists of science. "Normal science" is the routine practice in which all but a handful of scientists are involved. The conditions for "revolution" in basic theory arise when a given theory can no longer account for experimental evidence. The process of creating requisite theoretical change is individualistic and much less predictable than the routine concerns of "normal science." It is in the area of "normal science" that the "structure of science" which is our main concern here operates.

One general orientation of all of these examinations of science has been to detail the inner logic, the intellectual structure, of scientific knowledge. Extension of these ideas, and their location in the literature on the social structure of science provide theoretical rationale for the "autonomy" of science. Science proceeds from within. Permitting scientists to identify their own problems and methods safeguards science.

The activities of science, and particularly the activities of what Kuhn refers to as "normal" science,[4] the process of articulating and testing a given theory, are asserted to take place most effectively in settings which possess identifiable structural properties. As detailed in Merton's 1942 essay[5] on this topic the important characteristics of the structure of science are the adherence of participants to "four sets of institutional imperatives:"

(1) Universalism--"...truth claims, whatever their source, are to be subjected to pre-established impersonal criteria."[6]

(2) Communism--"The substantive findings of science are a product of social collaboration and are assigned to the community...The scientist's claim to 'his' intellectual 'property' is limited to that of recognition and esteem which, if the institution functions with a modicum of efficiency is roughly commensurate with the significance of the increments brought to the common fund of knowledge."[7]

(3) Disinterestedness -- "A passion for knowledge, idle curiosity, altruistic concern with the benefit of humanity and a host of other special motives have been attributed to the scientist. The quest for

distinctive motives appears to have been misdirected. It is rather a distinctive pattern of institutional control of a wide range of motives which characterize the behaviour of scientists."[8]

(4) Organized Skepticism--"The suspension of judgement until the facts are at hand, and the detailed scrutiny of beliefs in terms of empirical and logical criteria."[9]

Subsequent contributions expanded this analysis by detailing the maintenance and general workings of the structure outlined by Merton.[10] The most important condition emphasized was the element of competition between scientists. Autonomy allows science to proceed from within; scientists select problems for their intrinsic, theoretical interest. Competition for recognition and other rewards keeps intellectual productivity high and helps focus activity on areas commonly viewed as theoretically important. Work in this area can thus be separated into the attempt to provide answers to two related questions. First, what maintains the properties of science as a body of knowledge? Specifically, what maintains logical and systematic rigour, and the continuous collection and application of data to theory? Second, what characteristics facilitate commitment of scientists to intellectual endeavour? That is, what motivates scientists?

Answers to questions concerning motivation have emphasized "training" and "professional recognition."[11] Scientists learn the normative structure of science during their early training. Subsequently they are motivated by the learned desire for recognition from colleagues. While the concern for recognition is sometimes strenuously denied, and while open soliciting of recognition violates the norm of disinterestedness, colleague esteem is, nevertheless, clearly the main institutional support for commitment. The achievement of recognition (citation practices, the awarding of honours within professional societies, the naming of discoveries after their progenitors, and informal patterns of deference between members of disciplines) reinforces individualistic commitment patterns of "intellectual interest" in science. Thus competition for various prestige and monetary rewards allocated by colleagues is a primary concern in the literature.

Some answers to the first question have been found not only by viewing the consequences of the motivational structures described above, but also by looking at the requisites of science as a body of knowledge. Important here are a number of factors. First, patterns of communication supposedly keep intellectual standards high by exposing work for the criticism of the scientific

community. Availability of publication opportunities in journals, together with publication standards which require the detailed reporting of the methodological and procedural aspects of science ensure that work can be assessed according to both its theoretical and empirical import. Second, emphasis has been placed on the autonomy of researchers. Scientific advance springs from within science itself. "Problems" of concern to scientists are defined by theoretical systems within disciplines. Since these theoretical systems are only fully understood by the specialists themselves, and since the methods appropriate to examination of the problems are similarly complex, science can only advance if scientists are given the autonomy to define and pursue their research objectives as they please. Thus a very important property of the structures surrounding science has come to be emphasized, the characteristic "autonomy" or independence."

Autonomy embraces two themes: First is the necessary freedom of science structures from outside control. "Academic freedom" in this context is the independence of internal university activities from outside interference. Second is the emphasis on structures which supposedly ensure the autonomy of individual researchers. Egalitarian, colleague relation-

ships are believed to promote assessment of researchers by criteria of scholarly merit (i.e. objectivity) and hence to contribute to high levels of scientific motivation. Structures with well defined and extensive authority patterns engender the risk that position along the superior-subordinate dimension will extend into scholarly assessment to the detriment of the research efforts. The general view of science created by sociologists is one in which freedom of communication, and peer evaluation of performance promote normal science, while structural autonomy and individual freedom maximize the possibilities of advances in scientific knowledge. Competition among scientists serves to keep productivity levels high while ensuring focus on important theoretically defined issues. Perhaps the most important deviation of this literature from popular conceptions of science is its emphasis on the routine of science. The image of a lone individual creating knowledge is replaced by the presence of structures not dissimilar from those which operate in other professional settings.

B. The Sociology of Science: Some Comments on Evidence

We have attempted to give an outline of the main ideas in this general area. References to the evidence on these propositions have not been introduced, for to do so would require a major effort beyond the scope of this

report. An overview of the evidence bearing on the theoretical literature, however, indicates that while the data do not falsify the stated theory, they do not bear directly on some of the major theorems. In general it is descriptive rather than analytic. The literature is generally insightful, has considerable intuitive appeal, and is supported by impressionistic, first-hand observation of the operation of contemporary scientific research; but it should be approached with the same skepticism that the literature attributes to the processes of science.

C. A Critique of the Sociology of Science

A starting point for a more systematic evaluation is to note the closeness of ideas expressed in the theory to what might be described as "faculty ideology." The Sociology of Science suggests that what is best for science is the maximum freedom of researchers to do as they please. While this criticism is somewhat *ad hominem*, it does lead to suspicions about the objectivity of the ideas, a problem which plagues social science generally. Further substantive criticisms can be advanced, the first dealing with the overfocus of the literature on "basic" science, the second with money.

(1) The Emphasis on Basic Science

It is conventional to divide scientific activity into categories such as "basic," "applied," "mission oriented,"

"project development," etc. While usage varies somewhat, these categories span a dimension which at one end involves research whose import is measured by its centrality to theoretical systems and which at the other end involves the more mundane work of, for example, perfecting a new drug. Discussion of this issue is complicated by the problem of what constitutes potentially applicable knowledge and by the existence of "applied" disciplines. For example, research in particle physics and on DNA would both be considered "basic" research, but the _foreseeable_ applications of the latter are considerably greater. "Basic" research in the "applied disciplines" must also be considered. For example, "aerospace" would be considered an applied discipline, a relatively abstract branch of engineering; but within this area a researcher may be working on a "basic" problem (e.g. turbulence in gas flow) and the research may have no obvious application to current rocketry.

The general problem is an important one from the policy-making viewpoint. The most important investment a society can make is in knowledge which will ultimately be useful. The vast majority of all "applied," "mission oriented" and "project development" science is, however, ultimately dependent on knowledge which was once "basic."

The application of knowledge can only follow the knowledge itself. Thus the problematic aspect of decision-making is to predict which areas of basic research are likely to be most fruitful at some uncertain future point.

The Sociology of Science is not helpful on the question of applied research generally, and particularly in the area of applied research in universities. This is precisely because it considers conditions conducive to basic science. The ultimate centrality of basic science to all science is a good theoretical rationale for considering this first, but does not solve the policy-making problem. The relevant question becomes that of deciding the extent to which ideas on basic science are applicable to "mission-oriented" research. Are the conditions for high productivity in applied science similar to those in basic science?

Several arguments imply that this is not the case:
(a) It has been suggested[12] that large scale mission-oriented research is better organized hierarchically in opposition to the university's egalitarian structure. This argument is stated coincident with another--the need for cross-disciplinary work in mission-oriented research. Hierarchy is a means of both breaking down disciplinary barriers and co-ordinating progress towards an objective. It thus could be argued here that hierarchy

is only made necessary by the disciplinary orientations of researchers, and were these to be broken down elsewhere (say in university training), hierarchy would be unnecessary even in mission-oriented research.

(b) Most research outside universities (and most of the research at the "project-development" end of the spectrum is outside these institutions) takes place in relatively non-egalitarian situations. In industrial research laboratories, researchers tend to be assigned tasks.[13] But again criticisms can be voiced: while industrial researchers are told what to do, it is not likely they are told how to do it. Chains of command do exist within these situations, but they do not involve the continuous exercise of authority by those in command. Thus hierarchies in these situations may be nominal. Second, there is the possibility that hierarchy here may be explained in terms other than its efficiency for the research enterprise. Allowing researchers to define and pursue their own tasks may threaten the job security of powerful members of the organization. Hierarchy could be viewed here simply as an organizational response to the threat of innovation in moribund bureaucracies. It may also result in the demand that researchers pursue tasks they know to be fruitless.

The easiest way to sort out these confusions appears to be to distinguish between "means" and "ends." Researchers permitted autonomy over both, given their training and the orientations of their peers, typically seek to work on "basic problems." This clearly would be unsatisfactory in any applied setting where definitions of problems are given by the needs of the organization. Some means must be found of controlling basic orientations, and authority structures plausibly do this. On the other hand, if authority extends also into the domain of means, productivity is likely to be threatened. Thus the important element of autonomy in applied settings is most likely the freedom to choose ways of solving problems, that is, autonomy over means.

Again, there is surface plausibility to arguments which suggest that criticism and communication within mission-oriented teams are important here as elsewhere in science. Evaluating research is as important for practical application as it is for basic science. It follows that the structures which recommend themselves for applied research are those in which the ends of research are fairly tightly controlled, while other elements of the operation of the structure of science are essentially the same. In addition, but depending on the specific nature of the problem, various forms of interdisciplinary collaboration may be necessary.

(2) The Role of Money in Scientific Research

Another remarkable feature of the literature on the Sociology of Science is its failure to talk about money. It is clear that the rise of U.S. science has a great deal to do with the vast sums of money made available in the U.S. for scientific research, particularly after World War II. While there was a time when scientific research could be conducted by interested persons with interest a sufficient condition for the attempt (albeit an unsuccessful one unless other conditions were met), absence of distinction between professionals and amateurs is long past. Pre-requisites for scientific activity are expensive facilities, equipment, and specialized assistance. It could thus reasonably be argued that the scientific pre-eminence of a nation is now explained by the availability of money for science, and that what I have referred to as the "structure of science" comes into effect only to explain some small residual left unexplained by the more important "resource" factor.

(3) Differences by Discipline

It is important to raise one additional point. It was suggested above that the Sociology of Science has focused on "basic" disciplines to the exclusion of "applied" ones. The focus on disciplines is, of course, more narrow than this split alone. The focus has been on the conventional

sciences to the exclusion of social science. The failure of the social sciences (particularly political science, sociology and psychology) to develop viable theoretical systems is alarming given the fact that their institutionalization conforms exactly to the kind of structures claimed to promote science. These failings can be attributed partially to the intractability of the subject matter of these disciplines and also to the relatively short period of time they have been in existence: but taken at face value, the social sciences tend to disconfirm rather than confirm the theories in this area. Though this issue is a contentious one in social science, many academics view the isomorphisms of these disciplines with the structure of the natural sciences as resulting in a "piling higher and deeper" of writing of dubious quality.

Notes - Chapter III

1. William Kornhauser, Scientists in Industry (Berkeley, University of California Press, 1968).
2. In particular, Carl G. Hempel, The Philosophy of Natural Science (Englewood Cliffs, N.J., Prentice Hall, Inc., 1966), and Ernest Nagel, The Structure of Science (N.Y., Harcourt, Brace and World, Inc., 1961).
3. Thomas S. Kuhn, The Structure of Scientific Revolutions (Toronto, University of Toronto Press, 1962).
4. Ibid., Ch. III.
5. Robert K. Merton, "Science and Democratic Social Structure," Ch. 16 in revised edition Social Theory and Social Structure (Glencoe, Illinois, The Free Press, 1957).
6. Ibid., 553.
7. Ibid., 556.
8. Ibid., 559.
9. Ibid., 560.
10. For a brief summary of this literature see Norman W. Storer, The Social System of Science (Toronto, Holt, Rinehart and Winston, Inc., 1966).
11. See particularly Warren O. Hagstrom, The Scientific Community (N.Y., Basic Books, 1965).

12. Alvin M. Weinberg, *Reflections on Big Science* (Cambridge, Mass., Massachusetts Institute of Technology, 1967), 14, 130-132 and 145.

13. Kornhauser, *op. cit.*, 56-73.

IV. Research Support and the Orientations of Research in Ontario Universities

A. Background: The Policies of the Councils

The Sociology of Science literature summarized in the preceding chapter is of direct relevance to the analysis of research in Ontario universities. No check has been placed on the direction of academic interests by the present structure of research funding in Canada. Thus university research activity has concentrated on areas of within-discipline concern, on "basic" or "pure" knowledge. The councils have played the primary role in creating this emphasis. The effect of the Councils' emphasis has been peculiar in that it has been established more by the absence of a formal science policy than by coherent direction of federal spending. Thus the Committee on Science Policy (La Montagne) Report recently commented "...since 1916 the Canadian government has been searching for effective mechanisms to plan and co-ordinate science activities and has not been able to find them."[1] Nevertheless, identifiable and persistent features of the method by which the Councils (particularly NRC, which provides most money and has been in existence longest) allocate money to universities have resulted in a "de facto" science policy in this area. The major effect of this hidden policy has been to facilitate operation of the "structure of science" described at some

length above. The key elements of Council policy have been, first, the principle that initiative for obtaining research funds should come from the researcher as a proposal and second, that these proposals should be assessed by the researcher's peers. Both NRC[2] and its offspring of the late 60s, MRC[3], are similar in this respect, and accomplish peer-assessment via a system of committees in discipline areas. The Canada Council appears to employ a more centralized system based on reports by individual advisors and juries but with "the final stages of adjudication borne by the Advisory Academic Panel...of eighteen members drawn from universities across the country."[4]

Most of the money received by universities from the Councils comes in the form of grants-in-aid of research. It is with this category of money and with NRC's and MRC's "negotiated development grants," that we are primarily concerned here. No attempt is made in this report to examine the distribution or impact on universities of the various forms of scholarships and fellowships which are also provided by the Councils. For both NRC and MRC grants-in-aid of research are the major category of expenditure, accounting in 1969-70 for 64 per cent of NRC's direct university support[5] and 67 per cent of MRC's university support.[6] The Canada Council has a relatively low percentage of money in its Humanities and Social Science program in research grants (25 per cent)[7] and a high proportion in

doctoral fellowships (63 per cent).[8] Again, this reflects the low levels of research activity in most of the Canada Council-funded disciplines, and also the fact that in disciplines where research is inexpensive, support such as faculty fellowships is a form of research support.

Money which is parceled out as grants-in-aid is received by researchers in relatively small amounts. Of course, there is variation by Council. For the Canada Council, the mean grant size in 1969-70 was just over $500.[9] The NRC figure for Ontario universities <u>only</u> was $7,933[10]; the MRC figure for the whole of Canada was approximately $14,000.[11] It should be noted that grants from Councils do not usually include money for faculty time, or for indirect costs incurred by universities through support of facilities used for research.

Both NRC and MRC have, however, developed programs of support for areas of university research which require major funding. These involve two categories of money. "Negotiated Development Grants" are awarded by both NRC and MRC, and normally cover an extended time period; grants-in-aid of research are normally for one year only. The patterns of support in Ontario for NRC Negotiated Development Grants are shown in Appendix Two. Negotiated Development Grants (NDG's) constituted 3 per cent of MRC's 1969-70 university support program, and 9 per cent of NRC's total direct university support in the same year.

Over the past decade, NRC policy has undergone a shift relative to Negotiated Development Grants. In the early sixties NDG's were given primarily for support of expensive facilities, such as accelerators, in particle physics. In the mid-sixties, as money for NDG's increased, other areas were included for support. In 1970, NRC indicated these grants would become increasingly oriented to "problems of overall national importance."[14] This is in line with the Science Council's decision to channel science funds toward broad objectives relevant to Canada: "To permit this channeling it is proposed that most new undertakings in Canadian science be organized as large, multidisciplinary, mission-oriented projects having as a goal the solution of some important economic or social problem and in which all sectors of the scientific community must participate on an equal footing."[15]

Two prototype major undertakings of this sort were proposed: a program in space research and in "water resources management and development."[16] Also, four areas for immediate planning ("Transportation, Urban Development, Computer Applications, and Scientific and Technological Aid to developing areas of the world"[17]) were listed. At the same time as NRC declared its intention to re-orient its Negotiated Development Grants, MRC awarded its first large grant in a new program designed to bring together basic and applied researchers in multidisciplinary teams ("Medical Research Council Groups").

In addition, considerable support of university computer facilities has been undertaken by NRC. The support received by Ontario universities for computer facilities is summarized in Appendix Three. This support was reduced in 1970-71, however, and now the form of support has also changed. Whereas throughout the 60s substantial money was provided as block grants to university computing facilities, 25 per cent of computing costs are now budgeted into research grants. NRC estimated that this would effectively halve their support of computing costs for 1971-72.[18]

Large scale research and facility support from the Councils is important because of its impact on universities. This general area of funding (referred to here as "facilities support") tends to build the research potential of the university by supporting expensive research facilities, research institutes, and by building areas of expertise. The kind of research supported by these grants is much more distinct from the teaching (particularly undergraduate teaching) activities of universities than are the smaller "grants-in-aid of research." Negotiated Development Grants and aid for computer facilities tend to increase the capacity of universities to do research whereas grants-in-aid primarily support on-going research. Support for continuing research generated via NDG's must be sought ultimately in the Councils' other categories of award or from other funding agencies.

B. Research Support and the Operation of the Structure of Science

The universities' commitment to pure knowledge and to basic research is a recurrent theme of almost all Ontario universities' pronunciations on the topic of research. This is evidenced in recent submissions to the Ontario Committee on University Affairs. For example, McMaster stated, "Although the Policy of the Science and Engineering division is to give active encouragement to our faculty to undertake research having socio-economic relevance, we continue to believe that our main mission in the realm of research is to tackle problems of fundamental significance."[19]

Similar ideas were prevalent in briefs presented at the hearings of the federal Senate Special Committee on Science Policy. For example, the Faculty of Science at York University suggested that, "The universities should continue to be accepted by Federal and Provincial Governments as the most important source of pure science in the country."[20] Similarly, the research advisory board of the University of Guelph argued, "The university setting is ideal for fundamental research aimed at extending the theoretical background for scientific and technical progress as well as for the advancement of knowledge in general. The university campus in Canada should be a major source of the new fundamental knowledge produced in Canada in most areas."[21]

Emphases on basic knowledge are not surprising given the normal operation of the structure of science. Furthermore, Canadian research funding orientations exactly fit this structure. In Chapter Three it was suggested that organization by discipline, theoretical systems within these disciplines, and the "professional" structures of science, (particularly the element of competition) all generate activity on problems identified by theories within disciplines. Since these structures are internally well integrated, pervasive, and perpetuate themselves over time through the processes of graduate education, only some consistent assault could be expected to change the "basic" nature of research. Canadian science policy has given an essentially free reign to the operation of the within-university "structure of science" so that orientations to basic science are scarcely surprising.

At the same time, it is important to note one major deviation from this pattern--the research funded by the Medical Research Council. By its very nature, much medical research is applied research. This orientation is maintained not by the structure of MRC's funding, but by the different disciplinary structure of medical research. Medical research retains its applied orientation because researchers tend to operate in dual structures: science structures within universities, and "professional" structures composed of medical practitioners. The two reference groups, academics on one

hand, and physicians on the other, create much stronger pressures for applied research. Applied research is thus much more prevalent, not least because many researchers are directly involved in practice and application. Similar statements are true, though to a lesser extent, of engineering. Both these areas are examined below. It should be noted for the purposes of what follows in this section, however, that much research funded by MRC is an exception.

With this exception in mind, it may still be emphasised that the tendency toward "basic research" is a consequence of structural features, and not of the whim of individual researchers. This important point is one which critics of the "ivory tower" university often fail to comprehend. Expecting university researchers to take into account the practical "usefulness" of what they do, and to do this pragmatic weighing on their own individual initiative, is in its way just as naive as expecting businessmen to abandon the profit motive and pursue some conception of the "collective good" as their direct objective. The businessman who declares unilateral war on pollution will experience difficulty in our present competitive structure, because he faces competitors who are less benevolent. Analagously, the researcher also operates within competitive structures. If he turns to project development he may lose the praise of his colleagues, and ultimately be forced to seek another job.

In academic circles, applied science is frequently taken to imply second-rate science and is treated accordingly.

These two conditions in Canada--the operation of science's social structure, and the general "fit" with this of the funding system--are conducive to the continued production by universities of "basic knowledge." Any attempt to redirect science in Canada must therefore begin by changing one of these conditions. Changing the first, operation of the structure of science, is an impossible task. It implies direct intervention in the universities, and would require an assault on the learned orientations and motivation patterns which are the very basis of knowledge production in universities. These features of universities are unlikely to be changed by fiat. Much more feasible is a redirection of research income via the alteration of funding policies.

Despite what appear to be widely shared intentions between the funding Councils and the Science Council to re-orient spending toward areas of "national need," there is nothing about this supposed re-orientation which has yet made very much impact on the funding of university research. First, the agencies seem committed to leaving their programs of grants-in-aid to individual researchers untouched. Thus the major portion of their spending activity will not

change, and support of basic science is likely to continue. Second, the extent to which the program of Negotiated Development Grants will be changed remains to be seen. Even if this re-orientation were drastic it would probably take at least a decade for the appropriate centres to be built up, and for them to change the direction of university science appreciably. Even under these circumstances, the emphasis is still likely to be on "basic knowledge in mission-oriented areas." Thus, the "basic" thrust of university research in Ontario universities has been in part a consequence of the structure of funding, and is unlikely to be changed in the near future.

A recent report on engineering education in Ontario was critical of NRC's past performance on exactly this score:

> There has been a tendency over the past two decades for the topics of engineering doctoral theses to bear a stronger resemblance to physics than to engineering...In the university research laboratories of Canada, the majority of projects have been funded by grants from the National Research Council, whose committees were accustomed to allocating support to individuals for projects in the areas of pure science and who gave the appearance of having little knowledge of engineering research, or of the rapidly growing resource of engineering academic personnel. It was learned that the more closely an engineering proposal resembled one in pure chemistry or physics, the greater was the chance of receiving adequate funds. This pattern has been changed, due in large part to the vigorous and vociferous

> activity of the National Committee of Deans of Engineering and Applied Science. But the memory lingers on, and in our graduate research laboratories there continues to be a disproportionately large amount of analysis, compared to the rather modest activity of synthesis--the real essence of engineering.[22]

(C) Some Comments on the Effectiveness of the Structure of Science

(1) Introduction

It is virtually impossible to provide detailed evidence on the extent to which the knowledge production efforts of Ontario universities are effective. Such an enterprise would require descriptions of achievements within disciplines as these achievements measured up to the prevailing standards and concerns of the relevant area of science. Not only would this require the kind of familiarity with the disciplines that only specialists have, but as a research task it is prodigious. Even relatively simple information such as quantitative data on research productivity does not exist for either Ontario in particular, or Canada generally.

Still, there are a number of scattered pieces of information which allow us to make some comment on the effectiveness of the science structure operating in Canada. None of the data bear directly on the quantity or quality of work done, but relate to other aspects of the operation of structure of science-aspects which are the independent

variables for the dependent productivity variables. For example, standards of faculty recruitment, availability of funds, the rigour with which applications for funds are reviewed, departmental administrative structures and similar factors have all been asserted to effect production of knowledge. Inasmuch as the theory outlined above is true, it can be used to comment on the operation of science in Ontario universities.

Evidence of this type must, however, be interpreted cautiously. First, since the evidence does not bear directly on quantity or quality of research output, there is the possibility of error here. For example, it could be that despite adverse conditions in the academic marketplace, Ontario universities have consistently recruited excellent faculty. Second, most of the data below have to be analysed at aggregate levels. Some of these data are for Canada as a whole, and Ontario may be vastly different (although in most cases we are able to comment on differences at this level). More seriously, aggregate data for Ontario obscure considerable differences existing between individual universities. For example, it is clear that Toronto and McMaster compete much more favourably for academic manpower than do Lakehead and Brock. Thus, information on Ontario obscures what are clearly pronounced differences

within Ontario. In Chapter Six of this report more detailed comment on the operation of "hierarchy" is provided. The data reported below do not allow for the operation of such effects.

(2) Competition for Research Funds

Information is available concerning operation of the structure of science in the area of competition for research funds. Despite both the small usual grant size, and the small total of research funds available in Canada relative to the U.S., there appears to have been little problem of access to research funds in Ontario universities.

Rejection rates are low for both NRC and the Canada Council, the two Councils for which data are available. There is a detailed study by Hettich on the Canada Council covering the periods 1956-66 and 1968-69.[23] This can be supplemented by data made available by the Canada Council for 1970-71. The overall Ontario rejection rate for the Canada Council, as measured by number of applications not funded as a percentage of total number of applications, was similar at the end and the beginning of the period (see Table IV.1). Table IV.2 shows the dollar rejection rates associated with these figures (i.e. dollars refused as a percentage of total dollars requested). Dollar rejection rates were higher at the end of the period, but it

appears generally that increases in Canada Council funds have kept level with increases in the demand for research money.

Data for the National Research Council are less comprehensive than for the Canada Council; this is unfortunate since NRC's activities are 3.5 times larger than those of Canada Council. NRC data cover a three-year period, by discipline and not by university. They are for the whole of Canada, and only for NRC's March competition. However, since approximately 90 per cent of applications are dealt with at this time, this last factor is not a serious defect. A more serious point is the lack of information on the dollar rejection rate. Thus NRC's low turn-down rate (see Table IV.3) could hide a much higher dollar rejection rate than is the case for the Canada Council.

Within these limitations of the NRC data, however, the availability of <u>some</u> research money for most researchers who seek funding should be emphasized. In the three-year period for which information exists, overall turn-down rates for NRC have been 9 per cent, 11 per cent, and 14 per cent.

Table IV.1

Canada Council Number of Applications and Number of Awards in Ontario Universities 1965-66 - 1970-71

	1965-66		1966-67		1967-68	
University	Applications	Awards	Applications	Awards	Applications	Awards
Brock	-	-	1	1	5	3
Carleton	6	5	12	10	15	14
Guelph	-	-	6	3	16	13
Lakehead	-	-	3	1	1	1
Laurentian	1	1	-	-	4	3
McMaster	3	3	13	9	19	17
Ottawa	7	5	14	8	21	17
Queen's	16	16	12	12	29	29
Royal Military College	2	2	4	2	3	3
Toronto	17	15	62	49	67	67
Trent	1	1	8	7	5	5
Waterloo	4	4	24	20	23	22
Western	8	6	13	11	33	32
Windsor	2	1	12	8	9	9
York	2	2	21	16	32	26
Totals	69	61	205	157	282	261

Source: (1) 1965-66 - 1968-69, Hettich, Walter, The Canada Council Program of Research Grants: An Analysis for 1965-66 to 1968-69. A Report by the Canada Council. (Ottawa, Canada Council, 1969), Table 2.2., 21.

(2) 1971, Data supplied by the Canada Council.

	1968-69		1970-71	
University	Applications	Awards	Applications	Awards
Brock	4	4	4	3
Carleton	29	26	36	31
Guelph	18	14	22	17
Lakehead	2	-	5	3
Laurentian	8	7	4	4
McMaster	27	25	23	21
Ottawa	31	29	25	22
Queen's	32	29	20	19
Royal Military College	7	7	2	1
Toronto	115	109	157	148
Trent	14	13	13	10
Waterloo	31	26	49	41
Western	36	33	47	40
Windsor	15	13	9	6
York	38	35	42	35
Total	407	370	458	401

Table IV.2

Canada Council Dollar Applications and Dollars Funded
in Ontario Universities 1965-66 to 1970-71

	1965-66		1966-67		1967-68	
University	Applications	Awards	Applications	Awards	Applications	Awards
Brock	-	-	1,550	1,550	37,587	4,202
Carleton	24,550	23,550	17,210	15,310	33,805	32,324
Guelph	-	-	16,325	11,275	55,974	29,919
Lakehead	-	-	2,350	1,000	4,200	4,200
Laurentian	7,800	4,000	-	-	11,436	9,281
McMaster	4,500	4,500	17,500	11,700	111,417	91,254
Ottawa	12,130	9,650	42,325	13,852	85,633	66,630
Queen's	66,674	54,505	35,106	35,106	142,406	142,406
Royal Military College	2,288	2,288	4,825	1,825	4,061	4,061
Toronto	34,024	29,524	196,773	180,937	264,549	264,549
Trent	1,500	1,500	15,795	14,295	8,045	8,045
Waterloo	5,400	5,400	51,190	45,790	81,805	74,960
Western	14,626	12,526	87,069	84,069	104,802	100,572
Windsor	3,000	1,500	13,250	9,022	23,676	23,676
York	26,535	24,535	29,547	25,007	211,764	177,260
Total	203,027	173,478	530,815	450,738	1,063,160	1,033,339

	1968-69		1970-71	
University	Applications	Awards	Applications	Awards
Brock	32,680	14,670	20,700	8,310
Carleton	170,370	100,748	146,135	96,926
Guelph	36,962	29,683	63,090	51,216
Lakehead	3,076	-	14,784	8,384
Laurentian	55,303	37,763	14,866	7,375
McMaster	84,553	63,483	130,688	93,359
Ottawa	101,789	78,976	102,693	95,293
Queen's	130,114	97,766	226,846	84,524
Royal Military College	9,528	9,528	3,647	865
Toronto	465,828	421,825	724,432	636,499
Trent	42,093	23,593	245,832	216,850
Waterloo	156,820	102,485	275,688	176,081
Western	89,406	84,327	294,672	177,013
Windsor	39,736	29,531	29,562	14,908
York	217,409	143,328	264,037	160,585
Total	1,635,667	1,237,760	2,557,666	1,828,188

Source (1) 1965-66 to 1968-69, Hettich, The Canada Council Program of Research Grants Table 2.3, 23.

(2) 1971, Data supplied by the Canada Council.

Table IV.3

National Research Council, Applicants for Operating Grants -

Comparisons of Turndown Rates, March 1969, March 1970, March 1971

Grant Selection Committee	March 1969 Applicants		March 1970 Applicants	
	Total Number	Rec'd Nil	Total Number	Rec'd Nil
	#	%	#	%
Biol - Animal	254	6.3	275	15.3
Biol - Cell	304	17.4	345	19.7
Biol - Plant	207	15.0	234	18.4
Biol - Population	314	16.9	318	16.7
Psychology	238	18.5	255	18.8
Chemistry	594	4.2	644	7.9
Physics	406	9.9	436	11.2
Space & Astronomy	122	6.6	140	7.9
Eng - Chem & Metal	278	8.6	294	8.2
Eng - Civil	176	10.2	193	11.9
Eng - Electrical	252	9.9	270	4.1
Eng - Mechanical	238	7.6	279	9.0
Earth Sciences	421	5.7	433	7.2
Comp & Inf Science	90	10.0	134	15.7
Mathematics	450	3.8	533	5.3
	4,344	9.3	4,783	11.0

Grant Selection Committee	March 1971 Applicants * Total Number	Rec'd Nil	Applicants + Reducible Number	Rec'd Nil
	#	%	#	%
Biol - Animal	287	12.9	188	19.7
Biol - Cell	319	14.7	219	21.5
Biol - Plant	268	16.4	206	21.4
Biol - Population	339	11.5	247	15.8
Psychology	238	22.7	142	38.0
Chemistry	656	12.7	564	14.7
Physics	475	12.2	424	13.7
Space & Astronomy	137	1.4	136	1.5
Eng - Chem & Metal	329	8.2	271	10.0
Eng - Civil	206	12.6	162	16.0
Eng - Electrical	314	10.2	311	10.3
Eng - Mechanical	303	10.6	206	15.5
Earth Science	461	5.9	372	7.3
Comp & Inf Science	162	18.5	153	19.6
Mathematics	638	7.8	556	9.0
	5,132	11.5	4,157	14.1

Source: Table supplied by Office of Grants and Scholarships, National Research Council.

Note: * includes people with 3-year grants
+ excludes people with 3-year grants

"Towards 2000" recently noted:

> In a recent year the scale of grants awarded by the National Research Council and the Medical Research Council covered approximately two-thirds of the full time faculty in the sciences, engineering, and medicine. In the same year the number of Canada Council grants was equivalent to about 60 per cent of full time faculty in the social sciences and humanities.[24]

Council support programs are oriented to allocation of money by merit and to competition among researchers for this money. Though this interpretation must be offered in a qualified way, the data available do not indicate that the levels of competition for research money are particularly high. As one cynical observer remarked, it is possible to infer from the NRC's 9 to 14 per cent turn-down rate, either that only just over 10 per cent of those who apply for funds are not "excellent," or that some of those who receive money are less than "excellent."

At the same time, it should also be noted that the picture here is certainly not unusual in comparison with the U.S., where research money has been even more freely available, and in even larger amounts. To believe that rigorous competition and assessment works at the research funding stage may be simply naive.

(3) Competition for Academic Positions

Other areas of the operation of the structure of science in both Canada and Ontario should be examined to determine

the extent to which productivity is ensured by features other than competition for funds. The second set of facts which may be brought to bear on this is concerned with hiring and promotion of faculty members. Again, direct information on university promotion and its relationship to the research performance of faculty members is not available; amassing such information would require a large scale data-gathering effort. There is a second study by Hettich which analyses some features of university systems which have direct effects or are consequences of university recruitment practices.[25] This study is oriented to the examination of social science and humanities, but also includes data on discipline groups for physical science. Specifically, it mentions the expansion in number of faculty positions in universities, and the qualifications and ages of existing faculty members. The data from Hettich are supplemented by statistics from DBS on the production of qualified academics (Ph.D.'s).

Numbers of faculty positions and rates of expansion by discipline groups are shown below for Canada (Table IV.4) and for Ontario (Table IV.5).

Comparison of these tables indicates that the expansion over the whole period, the within-discipline-group expansions, and the general pattern of expansion are relatively similar for Canada and Ontario. This similarity of pattern is

Table IV.4

Canada - Expansion of Faculty Positions by

Discipline Group 1956-57 to 1968-69

Discipline Group	No. 56-57	% Increase 56-57 58-59	No. 58-59	% Increase 58-59 60-61	No. 60-61	% Increase 60-61 63-64	No. 63-64	% Increase 63-64 65-66
Pure Humanities	827	15%	951	20%	1141	59%	1818	41%
Applied Humanities	163	-11%	145	17%	170	16%	197	29%
Pure Soc. Science	462	23%	566	26%	711	71%	1213	53%
Applied Soc. Science	541	26%	683	21%	827	39%	1153	30%
Pure Bio. Science	347	7%	370	11%	412	45%	597	27%
Applied Bio. Science	721	-1%	715	13%	808	28%	1036	22%
Pure Physic Science	779	19%	928	22%	1135	38%	1568	30%
Applied Physic. Science	502	16%	583	27%	741	27%	943	16%
Total	4342	14%	4941	20%	5945	43%	8525	33%

Discipline Group	No. 65-66	Increase 65-66 67-68	No. 67/68	Total Increase 56-57 67-68	Increase 56-57 67-68
Pure Humanities	2561	38%	3525	2698	326%
Applied Humanities	255	63%	416	253	155%
Pure Soc. Science	1853	53%	2844	2382	516%
Applied Soc. Science	1502	41%	2115	1574	291%
Pure Biol. Science	759	31%	996	549	158%
Applied Biol. Science	1268	57%	2002	1281	178%
Pure Phys. Science	2036	29%	2623	1844	237%
Applied Phys. Science	1097	35%	1479	977	195%
Total	11,331	41%	16,000	11,658	268%

Source: Hettich, "Growth and Characteristics of University Teaching Staff in the Social Sciences and Humanities," Tables 1 and 2.

Table IV.5

Ontario - Expansion of Faculty Positions by

Discipline Group 1956-57 to 1968-69

Discipline Group	No. 56-57	% Increase 56-57 58-59	No. 58-59	% Increase 58-59 60-61	No. 60-61	% Increase 60-61 63-64	No. 63-64	% Increase 63-64 65-66
Pure Humanities	348	18%	411	25%	513	40%	717	47%
Applied Humanities	70	-19%	57	-4%	55	16%	64	22%
Pure Social Science	202	21%	245	27%	312	56%	488	57%
Applied Soc. Science	158	28%	203	4%	212	20%	254	35%
Pure Bio. Science	154	4%	148	20%	178	35%	239	28%
Applied Bio. Science	343	-12%	302	2%	309	15%	354	14%
Pure Physic. Science	314	-2%	308	29%	396	40%	556	36%
Applied Physic. Science	185	13%	209	39%	291	29%	374	19%
Total	1,774	6%	1,883	20%	2,266	34%	3,046	36%

Discipline Group	No. 65-66	% Increase 65-66 67-68	No. 67-68	Total Increase 56-57 67-68	% Increase 56-57 67-68
Pure Humanities	1,055	46%	1,547	1,199	345%
Applied Humanities	78	53%	119	49	70%
Pure Soc. Science	767	56%	1,199	997	494%
Applied Soc. Science	342	51%	518	360	228%
Pure Bio. Science	307	39%	427	273	177%
Applied Bio. Science	405	142%	685	342	100%
Pure Physic. Science	754	30%	981	667	212%
Applied Physic. Science	444	40%	622	437	236%
Total	4,152	47%	6,098	4,924	278%

Source: Hettich, "Growth and Characteristics of University Teaching Staff in the Social Sciences and Humanities," Appendix B, Table B.4, 42.

partially to be expected since, in most discipline groups, between one-half and one-third of all academic positions in Canada are in Ontario. Nevertheless, the general Canadian picture is important because the nature of the academic job market is such that Ontario competes with the rest of Canada. Thus the supply of faculty for Ontario universities is, in part, a function of the demand for faculty elsewhere in Canada.

The pattern across discipline groups is also significant. The greatest expansion over the whole period (1956-57 to 1967-68) in both Canada and Ontario was in pure social science (516 per cent for Canada as a whole, 494 per cent for Ontario). The next highest area of expansion was pure humanities (Canada 326 per cent, Ontario 345 per cent). Pure physical science was next highest for Canada (237 per cent) but was slightly exceeded in Ontario by applied physical science (236 per cent for the latter compared with 212 per cent for pure physical science).

High rates of expansion are the pattern. The biological sciences (pure and applied) less than doubled, physical sciences approximately doubled while pure humanities increased by a factor of three and pure social science by a factor of five.

In light of the high demand for faculty over this period, it is interesting to match the information on expansion with data on the production of Ph.D.'s in Canada over the same time period. Table IV.6 shows available data for the time period.

Table IV.6

Canada - Increases in Number of Faculty, and Ph.D. Production

by Discipline Group 1961-62 to 1967-68

	No. of Ph.D's[a] awarded 60-61, 61-62, 62-63	Faculty[a] added 61-62, 62-63,63-64	No. of Ph.D.'s awarded 63-64 64-65	Faculty added 64-65,65-66	No. of Ph.D's awarded 65-66 66-67	Faculty added 66-67 67-68
Humanities	167	704	139	801	206	1125
Social Science	140	828	139	989	200	1114
Biological Science	295	413	274	394	338	971
Physical Science	380	433	407	468	558	587
Engineering and Applied Science	65	202	91	154	182	382

Note[a] These columns cover a three year period, all other columns are for two years.

Source: (1) Faculty data: Hettich "Growth and Characteristics of University Teaching Staff in the Social Sciences and Humanities 1956/57 to 1967/68" Table 2, 9.

(2) Ph.D.'s: DBS, 81-211

The first two columns contain data for three years; the remaining columns indicate two years. The assumption is that students who obtain their Ph.D.'s are available for employment at the beginning of the academic year immediately following granting of the Ph.D. Thus a student who obtains a Ph.D. in 1962-63 is considered to be employable in 1963-64. This, of course, is a much more realistic assumption for pure and applied sciences than it is for social science and humanities where students frequently move into the academic market before completing Ph.D.'s. Nevertheless, inasmuch as it would be generally agreed in humanities and social science that a Ph.D. is desirable, the table represents the discrepancy between ideal and actual standards. In addition, it should be noted that because of the lack of fit between DBS-Ph.D. groupings and Hettich's categories, we have been forced to collapse some of Hettich's categories. Thus pure and applied Humanities are grouped together, as are pure and applied Biological Sciences. This is unfortunate, since it mixes pure groups where Ph.D.'s are considered desirable with applied groups where very often the reverse is true. (Thus medical researchers receive other terminal degrees than the Ph.D., and applied humanities is very often a qualification where experience plays a major role.)[26]

Since the focus in Table IV.6 is on disciplines where the Ph.D. is an appropriate qualification, applied Social Science appointments and Ph.D.'s are excluded from the category "Social Science". Applied Humanities are small relative to the pure segment, so that comparisons between numbers of faculty positions and Ph.D.'s are meaningful for these two groups. The most serious category, however, is Biological Science where there are twice as many applied positions as there are pure. Since most applied positions are for medical faculty where terminal degrees other than the Ph.D. are available, discrepancies between increases in positions and numbers of Ph.D.'s are not meaningful; this category is therefore ignored in the text below.

Clearly, Canada is not the sole source of academic manpower. The supply estimated above is supplemented by returned Canadians who studied for graduate degrees abroad, as well as by the inflow of foreign Ph.D.'s. Discrepancies indicated in the table were made up from other countries. Other sources of supply are discussed in greater detail below.

The table does indicate that the high demand for academics was not met from within Canada in any of the discipline groups over the period 1961-63 to 1966-68. The short fall was most serious in social sciences and

humanities, and least serious in pure physical sciences, with Engineering and Applied Science falling between these two. At the same time, the competing non-university Ph.D. employment sector is considerably larger in science. Thus, universities are not necessarily the first job choice of science Ph.D.'s. Indeed, government laboratories, the main non-university employers in Canada, are frequently criticized for placing too much emphasis on basic science. Canadian Ph.D.'s probably view this employment much more favourably than U.S. Ph.D.'s view their major alternative, employment in industry.

It is also possible that the undersupply indicated in this table hides quite different patterns within disciplines. For example, perhaps Physics was over supplied, while Statistics was undersupplied. As late as 1968-69, 278 of 369 Ph.D.'s awarded in pure physical science were in physics, chemistry and mathematics.[27] At the same time, physics and chemistry are the major employing departments within the pure science category so that little can be inferred from this. Where Hettich provides information by discipline, in humanities and social sciences,high rates of expansion and low rates of Ph.D. production uniformly prevailed.

In any expanding system or expanding discipline within a university system, senior appointments are likely to be more problematic than junior ones. The manpower problem at junior

levels can be solved by replacing unsatisfactory faculty with new Ph.D.'s. At times when junior faculty members are in short supply, there is always the possibility of retaining, but not promoting, unsatisfactory faculty members whose employment can be terminated when there is an increased number of new Ph.D.'s. The "pool" of potential senior faculty is, however, fixed. Whereas every year the new Ph.D.'s add to the pool of potential junior faculty, the pool of senior faculty consists of a relatively bounded cohort of past Ph.D's. Any extension of the boundaries must be achieved by recruiting outside the system in question.

An extension of this argument suggests that the current oversupply of Ph.D.'s will do little to increase university competition at other than the most junior levels. It is becoming increasingly apparent that universities in Canada, particularly in physical sciences, have suddenly gone into over supply.[28] The physical sciences have experienced a slowing in expansion rates and may now have reached a relatively stable size. Also, the number of faculty has a direct bearing on the production of Ph.D.'s. But a time lag of approximately five to eight years means that students who entered graduate schools in the middle of high faculty-expansion period will, in effect, arrive on the market when the expansion has stopped.

These neophyte Ph.D.'s will not be in competition with those who entered academic employment three and four years ahead of them; such faculty are already several rungs up the promotion ladder and competition for promotion tends to occur within and not between ranks. Competition and standards will rise sharply, therefore, but only at the bottom appointment level. The point of increased competition will rise only as those in senior positions vacate their appointments by retirement.

There are two reasons for this pattern. First, faculty at the level of associate and above tend to hold tenured positions. This makes them immune to the competition at the bottom appointment levels. Second, decisions about appointments are generally made in relation to the market at a given level. Thus, departments look for associate professors from amongst those who are already associates or who have served as assistants for a number of years. Not only are fast promotions very often threatening, but there are features of the academic marketplace which make competition far from perfect. A person's entry point to this marketplace is of critical importance to his subsequent career. Not only does institutional location affect research possibilities, but the prestige of the institution to which a person is first appointed is also used to evaluate him subsequently. A first appointment at a low ranking institution tends to handicap an academic both

by stigmatizing him, and by restricting his productivity. Furthermore, a Ph.D. who fails to obtain an academic appointment and undertakes alternative employment will encounter great difficulties subsequently in obtaining an academic post. The pool of potential academic appointees at levels above the entry point, therefore, tends not only to be limited to those already in academic employ, but also to comprise people differentiated from each other in such a way that they do not really "compete".

To sum up, with the Canadian academic marketplace in a state of oversupply, standards may be expected to rise sharply, but initially at the bottom appointment level only. The point of improved standards will rise only as those in senior positions vacate their appointments by retirement.

Some detailed comments should be made about non-Canadian sources of academic manpower. As indicated above, two flows are relevant--returning Canadians who went to graduate school abroad, and immigrants. It has not been possible to locate data concerning the return flow of Canadians, though this could be accomplished using DBS faculty data and cross classifying location of highest degree by citizenship. Data on citizenship have been compiled recently for Ontario by the Committee of Ontario Universities. In Ontario, 61 per cent of academics

are Canadians, 12 per cent are British and 15 per cent are American. As might be expected, the lowest proportions of Canadians are in pure humanities (47 per cent) and pure social science (53 per cent). Considering the paucity of internal supply at the time, however, these figures are surprisingly high. The obvious conclusion is that either many immigrants have already become Canadian citizens (unlikely, since much recruitment has been very recent) or large numbers of Canadians have been trained abroad. Certainly, it is conventional wisdom that lack of Canadian graduate facilities in many areas forced Canadians to turn to the U.S., but what is not known is how many returned. The citizenship figures for humanities and social science may indicate the magnitude of this flow.

Whatever the specific interpretation, however, it is clear that Ontario universities have had to import a considerable proportion of their academic staffs from outside Canada, a phenomenon which again suggests a past situation of high demand and low supply. It is also interesting to note that the proportion of foreign citizens in physical science is also relatively high (36 per cent in pure biological science, 40 per cent in pure physical science, and 36 per cent in applied physical science.) This is despite the more satisfactory supply in this area and may well indicate the availability of non-university employment for Ph.D.'s in these areas, and hence a similar

situation to humanities and social science of overall high demand and low supply.

Despite all the qualifications entered above, none of the various pieces of data indicate that a favourable situation for the operation of the structure of science has prevailed. A more detailed study of faculty qualifications, productivity, mobility and related factors would not only provide definitive information on this score, but would also be a useful planning tool in restructuring funding and the Ontario university system. Data currently available suggest that, for most of the sixties, competition for faculty positions was low. Inasmuch as competition, excellence, and productivity are related, it can be expected that the latter two have suffered.

(4) Some Additional Consequences of Rapid Expansion

Two important side effects of expansion are worth noting. Hettich shows that in pure social sciences and pure humanities, the median age of faculty members has been falling. In contrast, in physical science, median age has remained constant (see Table IV.7).

Hettich's study also contains data concerning the proportion of faculty with Ph.D.'s. These data, for Canada from 1956-57 to 1967-68 and for Ontario in 1967-68 are

Table IV.7

Median Age of University Teachers in Canada by Discipline Group

Discipline	56-57	58-59	60-61	63-64	65-66	67-68
Pure Humanities	41.0	41.0	39.0	38.0	37.0	37.0
Applied Humanities	42.0	44.0	44.0	43.0	44.0	41.0
Pure Social Sciences	37.0	38.0	38.0	37.0	36.0	35.0
Applied Social Sciences	41.0	40.0	39.0	39.0	39.0	38.0
Pure Biological Sciences	40.0	40.0	40.0	40.0	38.0	39.0
Applied Biological Sciences	39.0	41.0	40.0	42.0	41.0	40.0
Pure Physical Sciences	37.0	38.0	37.0	37.0	36.0	36.0
Applied Physical Sciences	38.0	37.0	37.0	37.0	38.0	37.0

Source: Hettich, "Growth and Characteristics of University Teaching Staff in the Social Sciences and Humanities, 1956-57 to 1967-68," Table 7, 23

reproduced below (Table IV.8). A recruitment pattern similar to that suggested by the age data is indicated. Social sciences and humanities have had to recruit faculty who have not completed, or in some cases, are not attempting to complete, Ph.D.'s. Physical sciences, on the other hand, have been able to recruit completed Ph.D.'s fairly successfully throughout the period.

As Hettich notes, comparisons between applied disciplines are not meaningful.

> In many disciplines in this group, the Ph.D. is not an appropriate degree. Lawyers, medical doctors, dentists and veterinarians obtain other terminal degrees. In fields such as applied fine arts, on the other hand, competence will be measured by criteria of a less formalized nature, and the fact that less than 10 per cent of arts teachers have a doctorate is no reason for concern.[29]

Comparisons between pure disciplines are more meaningful. Here a pattern to be expected from the data on internal supply and demand of Ph.D.'s emerges. The proportion of faculty members in humanities with Ph.D.s fell over the period 1956-57 to 1967-68 from 45 per cent to 40 per cent. In pure social science the proportion remained constant, but relatively low (53 per cent in 1967-68). In contrast, the proportion of Ph.D.'s in the pure sciences and applied physical science rose over the period, although the proportion of Ph.D.'s in these disciplines,where the Ph.D. is normally considered to be a prerequisite,is low.

Table IV-8

Percentage of University Teachers in Canada Holding a Ph.D. Degree in 1956-57 — 1967-68 and Proportion of University Teachers in Ontario Holding a Ph.D. Degree 1967-68 By Discipline Group

	Canada						Ontario
Field	56-57	58-59	60-61	63-64	65-66	67-68	67-68
Pure Humanities	45	47	47	41	39	40	45
Applied Humanities	26	27	34	31	24	20	27
Pure Social Sciences	51	53	59	53	53	53	58
Applied Social Sciences	17	16	18	20	19	22	19
Pure Biological Sciences	62	65	66	67	69	75	75
Applied Biological Sciences	29	33	36	35	38	36	30
Pure Physical Sciences	67	68	70	68	71	73	81
Applied Physical Sciences	20	20	22	30	35	48	55

Source: Hettich, "Growth and Characteristics of University Teaching Staff in the Social Sciences and Humanities, 1956-57 to 1967-68," Table 6, 21

While data concerning patterns over time are for all of Canada, the proportion of Ph.D.'s by discipline group for Ontario is not markedly different; again this is in part because a large proportion of academic positions are in Ontario. Hettich's comparisons of Ontario with other areas suggest that Ontario has fared better than any other area, and that as a consequence Ontario's faculty qualifications are higher.

In general, auxiliary data indicate that competition has been highest where there has been most research--in physical science. While this in itself does not demonstrate that assessment has systematically centered on research, it does establish one necessary condition for this to occur. The next most important area for research, social science, has been in a much less favourable position and has expanded in Canada with very little research tradition. Arguments for a rapid expansion in social science research-money should therefore be approached with some skepticism since the institutional research-basis is weak.

(5) Comments on Recruitment Processes

Processes of recruitment and promotion are different under conditions of expansion. Processes of faculty assessment ultimately are disruptive to the operation of a department, and are probably much more consequential than

comparable decisions in industrial or administrative organizations, where decisions are made by virtue of an authority which also exists in the day-to-day relationships of members of the organization. One previously noted feature of the operation of the structure of science is the creation in universities of egalitarian, colleaguial relationships. Department members do not exercise authority over the teaching or research of colleagues and in this respect their employment situation is unlike most others.

Consequently, relationships within departments do not preserve the element of "distance: which characterizes relationships of superiors and subordinates in other organizations. In university departments where authority relationships are to a large extent unnecessary, "colleague" becomes also "friend", and any evaluation process ultimately is disruptive to these realtionships. Judgement is not only a process of evaluating a man's work but also, conceivably, the process of damning a friend. Various forms of decision-making relative to promotions are often instituted which moderate these tensions. First, a certain anonymity exists in large departments and anonymity reduces the disruptive aspects of assessment. (Many departments in Ontario were small at the beginning of the expansion process and it is thus unlikely that these mechanisms worked.) Vesting pro-

motion decisions in the hands of committees constituted by deans can also remove evaluation from the face to face departmental situations where it is disruptive. Third, deviation from the colleague relationship within departments, a superior/subordinate relationship between a "head" or "chairman" and other members, or between senior professors and their juniors, increases distance and reduces the disruption consequent upon evaluation. The last two solutions tend to deviate from the peer-evaluation which is conducive to productivity since they introduce an element of authority into assessment. Furthermore, since position is defined relative to an administrative hierarchy, and not according to scientific competence, there is a strong possibility that other criteria than research performance (particularly a person's "fit" with a stable administrative strategy) will play an important role in evaluation.

Canadian departments at the beginning of the expansion period were small even in the slower expanding physical sciences. Therefore anonymity probably did not ensure effective working of peer assessment. In fact, it seems that promotion policies were located in the hands of administrative officials, partly because there were few faculty to do the promotion. Similarly many departmental officers were semi-permanent or permanent heads.

It is not difficult to see the advantages that these kinds of structures offer in conditions of rapid expansion. Recruitment is time consuming as is the process of "peer assessment" generally, and for any particular decision the marginal return on the investment of a number of people in making the decision as opposed to leaving decisions to a dean or head is likely to be small. Furthermore, if market conditions are unfavourable, the limits of choice may be so narrowly defined as to make the whole conception of choice meaningless. It is only feasible to refuse promotions if a replacement of equal calibre can be found. While new Ph.D.'s have been available in physical science, it seems unlikely that the market at higher levels in physical science, and at all other levels in other discipline groups was favourable. It seems reasonable to suppose that faculty members would show little interest in a process of decision making where scope for real decision was small, where numbers of recruitments continuously had to be made, and hence where participation would have required large scale investments of time for very little return. There has so far probably been little reason for faculty to oppose centralization of assessment.

At the same time,what appear to be the prevalent structures of assessment and promotion deviate from the

structures of "colleague evaluation" discussed in the literature on the structure of science. Neither general structural features of universities over the period nor impressionistic evidence on prevalent assessment procedures lead to the expectation that operation of the structure of science has been very effective at the level of faculty hiring, firing and promotion.

(6) Tenure

This section cannot be concluded without a consideration of "tenure." "Towards 2,000" recently offered the following comment on tenure in Ontario:

> Contrary to widely held views tenure has not had a particularly long history in Ontario. What we have seen over the past few years, with a bull market situation for professors is a more easily obtained and an earlier granting of tenure under rules worked out between administrations and increasingly strong faculty associations.
>
> From the point of view of the professoriate the argument for tenure is that it is a mechanism to protect from political or other pressures or from arbitrary dismissal the scholar whose views, developed in the search for truth, might well come into conflict with those of the wider society or those in power (which often means the same thing). This may well be an outmoded argument for tenure. Even though we live in a politically volatile atmosphere now and will probably continue to do so, and even though Canada seems to be starting to experience a more authoritarian climate, it is doubtful that tenure as it now exists is necessary to safeguard professors, or that it is the only effective mechanism against arbitrary dismissal.[30]

Many faculty members who entered universities in Ontario during the period of rapid expansion in the sixties are now eligible for, or have already received, tenure. A recent survey by the Canadian Association of University Teachers[31] indicates that the period of time before consideration varies from three to six years. Many universities have specified maximum time periods for consideration, and where specified these never exceed six years.

It seems there are very few arguments which can be advanced to suggest that tenure promotes productivity. If anything, it would be expected from all the arguments concerning the importance of competition and peer assessment that the removal of a man from a position in which these things matter would have the effect of decreasing rather than increasing productivity, but again no data are available. If tenure-granting procedures operate strictly according to criteria of academic productivity, then perhaps there is some presumption that researchers who are granted tenure will go on being productive, but again it is important to note that a "bull market" existed and that promotion procedures in many places have by no means guaranteed peer assessment. A weak form of the argument here suggests that tenure has no effect on productivity; a strong form suggests that tenure has a negative effect.

(7) Summary

To summarize, none of the data in the general area of the operation of the structure of science suggest that university conditions in Ontario over the past decade have been such as to result in high levels of productivity. It should be emphasised that none of the data bear directly on quantity or quality of research output. Thus, these statements must remain speculative and dependent on relationships--for example between competition and productivity--not actually demonstrated to hold for the particular case under consideration.

D. Mission Oriented and Applied Research

(1) Medical Research

It was suggested above that the major exception to the "basic" thrust of university research effort is the research conducted in schools of medicine. This area is an exception not because of differences at the funding level, but because of differences which operate at the university level. Specifically, both the existence of a non-university reference group of practitioners, and the close tie between research and practical training serve to restrain university-related tendencies toward basic science.

A recent report by the Ontario Council of Deans of Medicine summarized this situation as follows: "There appear to be more individuals engaged in some form of 'clinical'

research than there are in 'basic' areas, although the total expenditure of funds on the 'basic' side closely approximates that on clinical research."[32]

At the same time there is some evidence even in this area of the tendency to neglect some important aspects of applied research. Thus, for example, the Report of the Ontario Council on Health commented on the weakness of medical research in the area of community service.

> The university health sciences centres, community and government must be concerned with both the acquisition of knowledge, and the application of knowledge so acquired. The latter can be achieved in two ways. One is to educate knowers and doers who, with knowledge and skill, will be distinguished future practitioners in the professions, and the other is to encourage investigators to attempt to solve the problems of society, thus advancing the public good.
>
> If the universities, communities and the government accept this philosophy...it would make it much more respectable than it is now to direct one's research efforts to questions of skill and not to confine them to questions of knowledge. For instance, it would be as intellectually acceptable to investigate how to deliver optimal health care to the public as to investigate the behaviour of the components of the living cell.33

Similarly, this report also argued for improving the standards of applied research,[34] and stressed the importance of interdisciplinary research.[35] Thus it appears that the

area of medical research has not been entirely free from problems generated by "basic science" orientations.

Despite these qualifications, however, the general area of medical research does suggest that the most effective transmission of basic into applied knowledge tends to take place when the research-educational community contains persons involved in all stages of the process from basic knowledge to application. Indeed the criticisms cited above support this idea by isolating a point where this translation process has broken down because of the failure to include in the community those skilled in the delivery of care.

(2) Engineering

Engineering is an area similar to medicine, although its contacts with applied activity have been more tenuous than medicine for two reasons. First, the training of students is much less tied to practice. Second, and partially as a consequence of this, faculty tend to be academics while the import of engineers as a reference group is small. Thus only 59 per cent of Ontario's engineering faculty are registered professional engineers.[36]

A number of elements of this tendency to basic orientation were identified and criticized by a recent Study of Engi-

neering Education in Ontario. Ph.D. dissertations tend to involve analysis rather than synthesis.[37] Contacts with industry have been weak, although recently established Industrial Research Institutes at McMaster, Waterloo and Windsor are now carrying out industrial research contracts.[38]

The recommendations of this same study suggest an analysis similar to that for medicine. Increases in the applicability of research are to be achieved by encouraging contact between the two sectors, industry and university, and by increasing the significance of practitioners for academic engineers. The former involves,for example encouragement of consulting,[39] the latter,membership in the Association of Professional Engineers of Ontario.[40]

(3) General

One important feature of the current funding of research is tending to increase, if not exactly applied research, at least "relevant" research. The shift in orientation that has occurred in Negotiated Development Grants has tended to encourage research in areas of "national interest."[41] Usually, (and probably increasingly), this is likely to involve "Institutes" where the cross-disciplinary implications of this kind of research are more effectively pursued. In a similar vein, NRC has also created various other mechanisms for increasing industry-university contact:

industrial post-doctoral fellowships, deferred scholarships for students,[42] and an increase in industrial representation on NRC's governing body.

It should be emphasized that this support is being undertaken after criticism,[43] and without changing the scope or nature of the major portion of NRC's program, grants-in-aid of research.[44] Thus, while this program will in the long run build expertise in "relevant" areas, there are no strong inducements for researchers to forsake basic science and thereby immediately strengthen these areas. Furthermore, it is too soon to discern the extent to which even the program of Negotiated Development Grants will re-orient.

(4) <u>The Ontario Institute for Studies in Education</u>

Finally, this section cannot be concluded without comment on the unique, and often controversial Ontario Institute for Studies in Education. Some of the expectations which appear to have been associated with OISE were naive. Specific reference here is to the expectation that OISE do successful development work. Whereas, in the physical sciences, the low level of development of "applied" work is usually a consequence of the orientation of researchers, in social science the problem of application is also frequently a problem of the absence of the requisite knowledge. In areas

where knowledge is absent, "development" is a process of inspired guesswork. OISE is an expensive way of institutionalizing guesswork, and there can be no guarantees of the requisite level of inspiration.

Second, these problems are compounded by principles of internal organization. On the one hand, internal organization involves the classic university departments, but with a greater frequency of applied departments such as "Educational Administration." Though changes last year in the internal organization of research have worked to counter this, the initial consequence of this organization was the definition of the usual within-discipline research problems rather than the cross-disciplinary research which is usually indicated in "applied" areas.

Finally, and again on a critical note, both the organization of OISE's funding from the province, and the internal distribution of research money effectively did away with competition. OISE initially received a block grant from the province to cover both research and other costs. Research money internally was allocated in lump sums to departments where a re-allocation between faculty members took place. Thus virtually no competition for research money existed.

Most of the deficiencies listed above have, however,

been remedied. The allocation of research funds has been centralized within the Institute and major areas for the concentration of resources identified. The major proportion of research money is placed in co-operative research programs in particular "major thrust" areas of OISE strength. Support for individual research is retained but at a lower level than previously.[45] Besides increasing inter-departmental co-operation, this change is also aimed at increasing the focus on development work which requires larger scale funding than most research. (The previous system of allocation tended to mitigate against development because (i) a large proportion of a department's resources had to be committed to a single area to do such work. With allocation at a department level this was unlikely since it required sacrifice of individual faculty projects. (ii) Basic research tended to be preferred.) In addition research proposals are now subject to review by Review Boards composed of members elected from departments.

These changes are not only structurally innovative and different from the more conventional organization of research funding, but they also increase internal competition for funds and encourage inter-disciplinary and development work. Competition for funds will of course also be increased by the provincial government's decision to end OISE's monopoly of educational research funds.

Whether these innovations will bear fruit only time will tell. Certainly the general conditions for research at OISE (teaching loads, facilities, etc.) are extraordinarily favourable.

Notes - Chapter Four

1. Towards A Science Policy for Canada, Report of the Senate Special Committee on Science Policy, Volume 1. A Critical Review: Past and Present (Ottawa, Queen's Printer, 1970), 111.
2. For a list of NRC's "Grant Selection Committees" see Annual Report on Support of University Research 1969-70 (Ottawa, National Research Council, 1970), 408-411.
3. For a list of MRC's "Grants Program Committees" see Annual Review 1969-70 (Ottawa, Medical Research Council, 1970), 6.
4. 13th Annual Report of the Canada Council 1969-70 (Ottawa, Canada Council, 1970), 8.
5. NRC Annual Report 1969-70, 15. (This percentage does not include General Research Grants, Negotiated Development Grants, or Support for Computer Facilities.)
6. MRC Annual Review 1969-70, 20. (Does not include Negotiated Development Grants.)
7. Canada Council, Annual Report 1969-70, 24 and 116.
8. Ibid., 19 and 116.
9. Ibid., 24.
10. Data supplied by the Office of Grants and Scholarships, NRC.
11. MRC, Annual Review 1969-70, 20 (Number of grants estimated.)

12. _Ibid._, 20.

13. NRC, _Annual Report 1969-70_, 15.

14. _Ibid._, 13.

15. _Towards a Science Policy for Canada_, Report No. 4, Science Council of Canada (Ottawa, Queen's Printer, 1969), 29.

16. _Ibid._, 36.

17. _Ibid._, 38.

18. NRC, _Special Announcement-Operating Grants and Computing Costs, 1971_.

19. McMaster University, _Submission to the Committee on University Affairs_ (Hamilton, McMaster University, 1970), 118.

20. _Towards A Science Policy for Canada_, 198.

21. _Ibid_.

22. _Ring of Iron: A Study of Engineering Education in Ontario_, A Report to the Committee of Presidents of Universities of Ontario (Toronto, Committee of Presidents of Universities of Ontario, 1970), 21.

23. Walter Hettich, _The Canada Council Programme of Research Grants: An Analysis for 1965/6 to 1968/9_, A Report by the Canada Council (Ottawa, Canada Council, 1969).

24. John Porter et al., Towards 2000: The Future of Post Secondary Education in Ontario (Toronto, McClelland and Stewart Ltd., 1971), 110.
25. Walter Hettich, Growth and Characteristics of University Teaching Staff in the Social Sciences and the Humanities 1956-57 to 1967-68, A Report by the Canada Council (Ottawa, Canada Council, 1969).
26. Ibid., 12.
27. DBS, 81-211 (1968-9), 51.
28. See Marjaleena Repo, I'm A Ph.D.: Who Needs the Ph.D.? (Toronto, University of Toronto Graduate Students Union, 1970). A number of other studies which suggest a similar situation are now in progress but are unavailable as yet.
29. W. Hettich, Op. Cit., 12.
30. John Porter et al., Towards 2000, 33.
31. Tenure in Institutions of Higher Education in Canada, C.A.U.T. Bulletin, 19, No. 2, (1971), 39-73.
32. Specialized Manpower Production and Research Development in Ontario Faculties of Medicine 1969-75 (Toronto, Ontario Council of Deans of Medicine, 1970), 6.
33. Report of the Ontario Council of Health on Health Research, Annex F., (Toronto, Ontario Department of Health, 1969), 19.
34. Ibid., 55.

35. *Ibid.*, 67-70.

36. *Ring of Iron*, *Op. Cit.*

37. *Ibid.*, 21.

38. *Ibid.*, 23.

39. *Ibid.*, 23.

40. *Ibid.*, 37.

41. NRC, *Annual Report 1969-70*, 13.

42. *Ibid.*, 12.

43. Particularly *Towards A Science Policy for Canada*.

44. NRC, *Annual Report 1969-70*, 13.

45. For a detailed description, see *Proposals for a Balanced Program of Research and Development* (Toronto, Office of Research and Development Studies, OISE, 1970).

V. Research and University Organization

A. Introduction: Universities as Organizations

(1) Centralization and Decentralization: The Theme of University Organization

Universities tend always to balance centralizing and decentralizing tendencies. Often, and particularly in tight-money situations, this balance is a precarious one. Pressures for decentralization come from the conventional organization of the university for administrative, particularly budget purposes, along disciplinary lines. Departments are not only administrative devices, but they also comprise persons who share relatively cohesive interests, based on the pursuit of common intellectual goals. It is primarily at a disciplinary level within the university that the "structure of science" operates. Important to this operation is the autonomy given to departments over course offerings, over the structure of specialist programs, and over the pursuit of research, all of which conventionally are only nominally controlled either by administrative or participatory structures (e.g. elective faculty or university councils, senates, etc.) which have supposed authority in these areas. Since the expertise and scholarly merit around which the structure of science operates are disciplinary and hence departmental matters, a general aura of "deference to competence" operates against cross-departmental judgements about the extent to which programs

of study or research are worthwhile. Criticisms of other departments are implicitly criticisms of other disciplines, and since faculty members define themselves as competent in their specialty and respect the competence of others it is unlikely that such criticisms would be voiced. The inability of universities to generate major reforms from within has a great deal to do with the egalitarian distribution of power across departments and the consequent unwillingness of faculty to embark upon discussions of the education offered.

The centralizing tendencies within universities spring from the fact that ultimately decisions have to be made about which department gets what. Perhaps the most important decisions have to do with (i) the number of faculty positions to be allocated to a department and (ii) the amount of facilities,particularly physical plant, a department is to receive. Since research demands and teaching needs often do not mesh with one another (for example, physics is likely to have a large amount of research money while sociology or psychology has many students) and since departments are unlikely to be able to resolve these matters between themselves, decisions made by central authority further help to avoid direct confrontations between departments.

Centralized decision-making also serves in the attempt to allocate funds and personnel according to more general concep-

tions of the "good of the university." Criteria involved in this process are often nebulous ones, and the weights assigned to various criteria are themselves subject to the pulls of subterranean politial currents of the university. Criteria involve such things as "university prestige", "balance" between programs, student residential accommodations, the need for "community" and so on. Not to be left out are more pragmatic and directly political considerations, such as relationships with those who provide the universities with income (national or local legislative bodies, research funding agencies, foundations, alumni, etc.).

The comparative data on university organization indicates a wide range of variation in levels of centralization in universities. One good indication of centralization is the nature of administrative appointments in universities. At one extreme are the prestigious U.S. universities where many line administrators below the president are academics who hold positions on a temporary basis. At the level of departments, the "chairmanship" is almost invariably an office which rotates between senior faculty members and the authority of which is severely limited in scope. In the U.K., administrators are much less likely to be academics and much more often permanent appointees, while heads of department (the title "head" rather than chairman being significant in this respect) occupy their positions in perpetuity.

Centralizing features, particularly within-department authority structures can operate against the structure of science by substituting superior/subordinate relations for assessment according to criteria of scientific merit. (German universities are a case in point.[1]) Interestingly, the prevalence and permanency of authority structures are not only independent factors which affect the operation of science, but are also in part dependent on this operation. The crucial factor here is again money.

(2) Centralizing and Decentralizing Effects of Income: Vertical and Horizontal Money-Flows.

Universities generally derive their income from several sources. The most important are (i) operating grants from governments (either local or national), (ii) student fees, (iii) income from endowments and gifts, (iv) research grants. The first three items (and in countries where higher education is free (i) and (ii) overlap substantially) come to the university "vertically;" that is, they are received and allocated centrally within the university. The fourth item, research money, is usually allocated by a sponsor to an individual faculty member. While "grants" are administered by the university, the money for practical purposes "belongs" to the faculty member, and unspent portions of the budget are returned to the sponsor. This money is

referred to below as "horizontal" income. All of the United States, the United Kingdom and Canada approximate this system for funding research.

The net effect of research funding has thus been to increase considerably the power and autonomy of the faculty member who can obtain research grants; the United States is certainly a case in point. Some of the decentralizing effect has to do with the simple money income generated. A professor whose salary is paid by research grants does not command a salary from the university, and as the "overhead" on research grants in the United States has increased, the "cost" of research to the university has declined to the point where it is unclear whether the university is supporting research or research the university. But beyond this, and beyond the ability of such faculty to support graduate students out of research grants, the academic engaged in research is a prestige asset to the university and since this is the domain in which universities compete, universities attempt to create favourable conditions for their active researchers. If a university fails to do this, the faculty member can move elsewhere, taking grants and graduate students with him. Where large parts of the university operations are supported on "soft" money from

research grants, or where the university is concerned about its prestige, threats to leave can be powerful.

If this is the situation in the United States, it is less so elsewhere. In the United Kingdom where the amount of money available is smaller, large proportions of the faculty are teachers rather than researchers. Teachers unlike researchers are "expendable," and the general power of faculty members other than those holding administrative posts is virtually non-existent. In addition, the smaller size of grants and different "overhead" practices mean that the loss of a researcher costs less in income terms.

Another striking feature of the university scene in the U.S. has been the absence for 20 years (again, particularly in prestigious universities) of any reinforcement of the centralizing tendencies. From the end of World War II, money for higher education in the U.S. flowed freely. Money from state legislatures seemed assured, government research support was expanding rapidly and alumni were giving. While problems were generated they had almost entirely to do with the rate at which universities were expanding research activities. This led to constant debates with the funding agencies over the amount of overhead to be charged to research.[2] But in general, with money relatively

freely available, decentralization could proceed without disrupting the organizations. Individual departments could expand and pursue their own objectives without the necessity of a central authority making decisions concerning competing objectives. Now, suddenly, everybody has stopped giving, and all is crisis and confusion.

B. Horizontal and Vertical Income in Ontario Universities

(1) Research Income and the Cost of Research

The inherent strain between centralizing and decentralizing characteristics of universities is particularly marked in the case of Ontario. Not only do administrative and departmental structures overlap in the usual way, but characteristics of university financing increase this tension. The conjunction of three features of funding is relevant.

(i) Horizontal and vertical income are clearly separated.

(ii) The horizontal, research income is insufficient to cover the full cost of research.

(iii) The vertical income which must be used to supplement the insufficient supply of horizontal income is tied via "formula financing" to teaching needs.

Many of the top research institutions in the U.S. have considerably greater financial flexibility that those in Canada, because they are privately controlled and possess large incomes from endowed funds. In 1967-68, of the 20 U.S. universities which received over $25 million in research

funds from the federal government, eleven are privately controlled,[3] and most of these have sizeable income from endowments. Ontario's largest university, Toronto, has "a meagre general endowment of $2 million."[4] Clearly, income derived from this amount could never generate much financial flexibility.

As pointed out above universities have little or no control over the inflow of horizontal research money. To attempt to control research income, administrations would have to interfere directly in the most jealously guarded faculty preserve--knowledge production. Furthermore, given the fact that lower levels of administration ("departments") coincide with disciplinary areas and that in any conflict over research, departmental officers' professional interests would predominate, no formal mechanisms exist which could exercise control over the acquisition of these funds. Thus, the acquisition of research money is only controlled by its availability from the funding agencies.

The policies of these agencies are such, however, that grants-in-aid of research only cover a portion of the cost of research. Not covered are both indirect costs (maintenance on building, secretarial time consumed, etc.) and certain direct costs such as faculty time. Thus the universities indirectly subsidize research by effectively reallo-

cating vertical income and footing the bill for items not covered by research grants.

Some impression of the potential magnitude of this problem can be obtained by examination of the percentage of university budgets devoted to research expenditure (see Table V.1). These are, of course, not actual expenditures but the figures universities routinely report as being expenditures, i.e. research income. As Table V.1 shows there is considerable variation in the budget "expended" on research. Toronto, Queen's and McMaster all "spent" over 17 per cent of their total ordinary expenditures on research in both 1968-69 and 1969-70. Brock, Lakehead and Laurentian, however, were all below 5 per cent in both years.

As suggested above, these are not the real expenditures for research, but rather income. Forming some estimate of the amount of money indirectly reallocated to research involves major methodological problems. Well-informed estimates of the amount of faculty time allocated to research as opposed to teaching are required, as well as the amount of facility-use devoted to research, and the proportion of administration activity involved in managing research, and the cost of all these. These sorts of data are enormously difficult to obtain. A recent study by the

Table V.2

Ontario Universities, Research Income, and Estimated Research Expenditures, 1969-70

University	($000's) Research Income	%Total Ordinary Operating Expenditure	($000's) Estimated Research Expenditure (Hettich formula)	%Total Ordinary Operating Expenditure
Brock	261	4.4%	1,533	25.9%
Carleton	1,664	8.0%	6,074	29.3%
Guelph	2,528	7.8%	9,456	29.0%
Lakehead	260	3.3%	1,978	25.1%
Laurentian	208	3.4%	1,529	25.0%
McMaster	5,961	18.3%	12,612	38.7%
Ottawa	2,990	9.4%	9,742	30.5%
Queen's	5,160	17.0%	11,350	37.6%
Toronto	18,255	17.3%	39,870	37.8%
Trent	377	7.4%	1,455	28.7%
Waterloo	4,182	12.4%	11,230	33.3%
Western	6,222	14.8%	14,937	35.5%
Windsor	1,089	6.8%	4,508	28.1%
York	2,241	8.7%	7,670	30.0%

Source: Research Income and Total Ordinary Operating Expenditure are from DBS-CAUBO Returns.

inflexible category. More likely only a portion of non-faculty costs would be so allocated, while the remainder would vary with research income.

These arguments, together with the initially dubious quality of the AUCC data by which the estimate was derived, cast the cost estimates in Table V.2 into grave doubt.

Unfortunately, no alternative way of estimating actual cost other than educated guesswork exists. It is, however, worth noting that the estimates can be taken as implying that for both Toronto and McMaster 20 per cent of faculty time is spent on research, and that overhead runs at 51 per cent for Toronto and 55 per cent for McMaster.* These are not implausible figures. Overhead in the U. S. is now this high, and, therefore at least for the larger universities there is some credibility to

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*We calculate these by arbitrarily assuming the 20 per cent figure for faculty time, and calculating cost for this as 20 per cent of expenditures for academic staff (see Table V.1). This figure is then added to research income to yield total direct cost of research. The difference between this total and the Hettich estimate is then taken as the figure for overhead. Percentage overhead cost is calculated using total direct cost as the base. A recent study at Queen's has estimated the mean figure for faculty time on research to be approximately 25 per cent.[9]

Association of Universities and Colleges of Canada attempted this task, but with dubious success.[5] The AUCC study is so hemmed with qualifications (including a withdrawal from sponsorship of the study by the Canadian Association of University Teachers)[6] that it could be argued the findings are more misleading than they are helpful.

Nevertheless Hettich,[7] using AUCC data, has recently formed an estimate of actual research costs. The technique used to do this is described as follows:

> The authors of the unit cost study prepared, for each institution in their sample, an estimate of total research costs. A regression analysis was conducted in order to determine whether research expenditures as calculated in the unit cost study were related systematically to other variables describing the institutions. The following regression was fitted:
>
> $$RE = .9172\ AR + .2191\ OE$$
> $$\quad\ (4.870) \qquad\quad (7.119)$$
> $$\bar{R}^2 = .983$$
>
> The symbols AR and OE stand for assisted research and total operating expenditures. T-ratios are given in brackets. As the value of $\bar{R}^2$ indicates the regression is highly successful in explaining variations in total resources for research (RE).[8]

Next, Hettich assumed that this relationship would apply to other institutions. If this assumption is made, the equation can be used to estimate actual research expenditures for any university where assisted research income and operating expenditures are known. Table V.2 shows estimated research expenditures for Ontario universities for 1969-70. The estimates are calculated using Hettich's formula and DBS-CAUBO data.

It is unclear whether or not this conforms to what might be expected on the basis of what is known concerning separate elements entering into the portion of research costs not covered by income. The two major items not covered are faculty time and cost of facilities. It seems plausible that expenditures on faculty time bear a direct relationship to research income. If this is the case, an estimate of research costs should plausibly begin by adding a simple percentage to research income for faculty time. Hettich's estimate, however, uses a figure slightly under the research income (.9172) and makes the sum added to research income a proportion (.2191) of operating expenditures.

Some rationale can be made for this on the grounds that cost of facilities for research does not vary with income for research. All universities tend to regard it as desirable that faculty do research since this activity brings prestige to the institution. Thus it could be that all universities erect, and then have to maintain, research facilities so that research is possible. In some universities these facilities would be underutilized, and this would explain the high estimate of research costs for low research institutions. At the same time it seems anomalous that all costs, or even all non-faculty costs should fall in this

Table V.1

Ontario Universities: Selected Categories of Expenditures 1968-69 and 1969-70

1968-69

	Expenditures for Academic Staff		Total Academic Expenditures		Expenditures for Assisted Research		Total Ordinary Operating Expenditure	
	$(000's)	%	$(000's)	%	$(000's)	%	$(000's)	%
Brock	1,343	33.3%	2,093	51.9%	162	4.0%	4,029	100%
Carleton	5,929	36.3%	9,553	58.4%	1,439	8.8%	16,353	100%
Guelph	8,698	30.2%	16,656	57.8%	2,129	7.4%	28,806	100%
Lakehead	1,990	34.4%	3,279	56.7%	170	2.9%	5,788	100%
Laurentian	1,722	37.1%	2,616	56.4%	136	2.9%	4,635	100%
McMaster	9,069	34.0%	14,172	53.2%	4,795	18.0%	26,653	100%
Ottawa	8,416	35.2%	13,296	55.5%	2,709	11.3%	23,902	100%
Queen's	9,122	35.6%	15,381	60.0%	4,866	19.0%	25,633	100%
Toronto	30,840	34.6%	50,718	56.9%	16,146	18.1%	89,182	100%
Trent	1,351	32.8%	1,894	46.0%	335	8.2%	4,116	100%
Waterloo	8,887	32.8%	16,432	60.6%	3,702	13.6%	27,125	100%
Western	11,203	32.9%	19,982	58.7%	5,821	17.1%	34,068	100%
Windsor	4,675	38.3%	6,897	56.5%	806	6.6%	12,211	100%
York	6,501	34.9%	11,460	61.5%	1,330	7.1%	18,636	100%

Source: DBS-CAUBO "Report of Financial Statistics of Universities and Colleges."

	Expenditures for Academic Staff $(000's)	%	Total Academic Expenditures $(000's)	%	Expenditures for Assisted Research $(000's)	%	Total Ordinary Operating Expenditure $(000's)	%
Brock	2,020	34.2%	3,310	56.0%	261	4.4%	5,906	100%
Carleton	7,399	35.7%	12,752	61.5%	1,664	8.0%	20,758	100%
Guelph	10,318	31.7%	19,230	59.0%	2,528	7.8%	32,577	100%
Lakehead	2,784	35.4%	4,596	58.4%	260	3.3%	7,875	100%
Laurentian	2,390	39.1%	3,547	58.0%	208	3.4%	6,108	100%
McMaster	10,872	33.3%	17,816	54.6%	5,961	18.3%	32,609	100%
Ottawa	11,747	36.8%	18,229	57.3%	2,990	9.4%	31,945	100%
Queen's	11,079	36.7%	18,225	60.4%	5,160	17.0%	30,203	100%
Toronto	36,247	34.3%	58,965	55.9%	18,255	17.3%	105,553	100%
Trent	1,946	38.4%	2,542	50.2%	377	7.4%	5,064	100%
Waterloo	11,684	34.6%	20,232	60.0%	4,182	12.4%	33,749	100%
Western	12,288	29.2%	25,302	60.0%	6,222	14.8%	42,128	100%
Windsor	6,708	41.9%	9,589	59.9%	1,089	6.8%	16,018	100%
York	9,650	37.7%	15,050	58.8%	2,241	8.7%	25,625	100%

Source: as per the last table.

the suggestion that every dollar of research income requires a matching dollar from vertical funds.* The prospects for long run stability under this system of financing are gloomy. Stability is maintained so long as the amount of vertical money is sufficiently large to cover not only teaching activity, but also to supplement research income by the required amount. The potential for crisis is set by the relative inability of universities to control the flow of horizontal money. Crisis is reached when the size of the vertical component is insufficient to add the necessary subsidy to the horizontal component without seriously disrupting other areas of university activity. This situation is of course arrived at by any rise in costs not offset by a rise in income. Under present research funding policy, however,

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*Further credibility is given to the size-range of research cost estimates formed in Table V.2 by the rationale adopted for estimating research costs in another report prepared for this Commission. In the Systems Research Group's report "Cost and Benefit Study of Post-Secondary Education in the Province of Ontario", universities' research expenditures are estimated as first 25% and then 50% of total university expenditures.

> "The rationale behind the choice of these somewhat arbitrary amounts is that the average undergraduate teaching load is approximately 3 undergraduate courses plus preparation time. The balance of time is devoted to research. The courses and preparation typically consume 20 to 30 hours of the teaching week, leaving approximately 10 to 20 hours for research. The mixed graduate and undergraduate load is typically one undergraduate, one graduate course, thesis supervision and the balance research. From these general guidelines it would appear that 25% and 50% are reasonable limits on the research expenditures."[10]

All the estimates of university research formed using Hettich's procedure fall within this 25% - 50% range.
(See Table V.2, Column 4)

any rise in research income actually represents a rise in university costs. According to Hettich's calculations, each dollar of research income must be supplemented by an additional dollar from vertical funds.

The increasing financial problems claimed by the University of Toronto may be a consequence of the fact that (horizontal) research income is now rising at a faster rate than vertical income. This would require that an increasing proportion of vertical money be redirected each year. Unfortunately we do not, at present, have the time series data which would allow analysis of changes in the categories of individual universities' expenditures and income over time. These data exist in the form of DBS-CAUBO returns, but were only readily available for 1968-69 and 1969-70. Information for previous years was not received in time for inclusion in this report.

At the same time specific changes are not essential to the generation of problems since any rise in costs greater than increases in income will have a similar effect. Problems of this sort are simply exacerbated by a university's low ability to control over 30 per cent of its expenditures. Thus aging of faculty and resultant

C. Research and Teaching

(1) Introduction

Researchers are prone to assert the "integral" relationship between research and teaching. More often than not these assertions are transparently partisan; seldom are they grounded in evidence.

> Research, including sponsored research, is not and cannot be a natural enemy of teaching. Indeed in the simpler definition of creative scholarship, research is essential to the process of higher education--the process of teaching and learning.
>
> Far from believing that research is a competitor or an enemy of higher education (or teaching if you will), I insist they are inseparable and that each is essential and complimentary to the other.[13]

While there is little evidence in this general area, a number of arguments have been advanced on the other side. First, there is often a large discrepancy in intellectual level (particularly in science) between a first year undergraduate course, and research. For this reason it is virtually impossible to involve undergraduates in research in any meaningful way. With research involvement for undergraduates not possible, the knowledge-production orientations of faculty tend to have a negative effect on undergraduate course offerings. Weinberg has argued that: "The professional purists, representing the spirit of the fragmented, research-oriented university, took over the curriculum reforms, and by their diligence and

aggressiveness created puristic monsters."[14] Weinberg also notes the importance from the point of view of undergraduate education of according the "generalist" the same status as the "specialist."[15] General questions may be raised about the extent to which research and junior undergraduate teaching are related to one another.

There is ample evidence from the U.S. to suggest that research and teaching tend to differentiate from each other. This involves two features: appointment of persons in universities as full or part-time researchers rather than teachers,[16] and recruitment of substantial numbers of low-paid, low-status, "teaching assistants" to do much of the day-to-day teaching.[17] This seems to indicate either that research is not essential to teaching (certainly that teaching is not essential to research) or that universities are prepared to ignore this "essentiality" in organizing teaching.

Accompanying the growing use of teaching assistants was a parallel growth in the number of research personnel in universities. Research in United States universities grew through the fifties and sixties,not only because regular faculty became more and more involved in research, but also because universities' full time researchers grew in numbers. The structural innovation of this period

Toronto, the university subsidy is low (in 1970, $117,350 out of a total research income of $432,950, plus office and workshop accommodation[11]). Nevertheless, current Council policy implies that Negotiated Development Grants are for fixed periods of time. The effect of this policy will be to create high research potential in highly specialized areas. If and when large scale support from NRC ceases, these areas are likely to be a drain on university resources.

This has visibly been the effect of the pattern of NRC's support for computer facilities. In the early sixties NRC began a program of heavy support for computer facilities. Computer facilities were clearly becoming increasingly important in research, and the acquisition by universities of such facilities became a prerequisite for large research income, and as such facilitated subsequent increases. Now, faced with a tight money situation, NRC has altered the nature of its support for computer facilities. This support will not be allocated as block grants, but by budgeting 25 per cent of computing costs into research grants. NRC anticipates this will cut its support in this ar a by half in 1971-72.[12]

Additional examples can be given where similar actions may occur. Queen's received $100,000 each of two successive

years (1968-69, 1969-70) for support of research in mathematics. This financing helped build a strong mathematics department which Queen's will undoubtedly wish to preserve. If this is to be done, once the NDG ends, (unless alternative large scale support can be found) Queen's is likely to have to subsidize research in this area from internal funds. Prospects for large scale support in pure science from agencies other than the Councils are small, and hence the reallocating effect described above will necessarily operate.

It can be seen that research is a complex, often paradoxical issue. Administrations of universities must encourage research; the prestige of the university is at stake. Any attempt to curtail research activity would quickly drive researchers elsewhere and the university would lose its reputation for excellence. Even if the desire to control research were present, the structural mechanisms required for control would not only produce conflict, but might destroy the institution involved.

At the same time, to leave research unchecked requires "squeezing" elsewhere. In the long run this squeeze is inevitably placed on the teaching of students.

salary increases, or salary increases according to the problems outlined in the introduction to this report, can act to increase costs, and hence internal problems.

Not all of the Ontario universities appear to be experiencing difficulties in this area at present. In fact, Toronto is the only university which claims to be having problems. There does not seem to be a single explanation for this. First, while Toronto draws most research income, this income relative to its size has been similar to that of McMaster, Western and Queen's. Simple size of income therefore does not account for the observed differences, since strains at these universities on the basis of income ought to be the same. A number of factors have, however, been suggested as explaining differences between Toronto and other universities:

(a) Toronto maintains more specialized research facilities (e.g. research institutes). Toronto has received more in large scale facilities support than other universities (see Appendices Two and Three, and argument below).

(b) Of the intensive research universities, others have been expanding faster than Toronto and this has brought them favourable money and space allocations. (This is not true of Queen's.)

(c) Toronto has older, more expensive buildings than other universities, thus maintenance costs are higher.

(d) Toronto's dual organization (colleges and university) has precluded Toronto "squeezing" humanities. (This phenomenon is analyzed in the next section.)

Any one or several of these factors, if severe enough, could account for the greater problems experienced by the University of Toronto.

(2) The Effects of "Facilities Support"

The general problem associated with research income may well be exacerbated by other features of research funding. While grants-in-aid of research constitute the major parts of the Councils' funding programs, there is another category of support-money previously referred to as "facilities" support. The money that Ontario universities have received in this category is given in detail in Appendix Two. Because these data were obtained by searching NRC's "Annual Reports on Support of University Research," and because there are shifts in the relevant categories over time, these data are probably incomplete and underestimate support in these categories.

It is unclear whether university subsidies to the areas which receive these block grants occur at the same rate as for research generally. Answering this question would require detailed information; in the one instance where detailed information exists--The Great Lakes Institute--at

which permitted this was the university research institute. Facilitated by the amount of money available, the multiplicity of agencies providing support, and the horizontal nature of this support, specialized research agencies were set up on numerous campuses. The advantage of such institutes was that they created faculty research opportunities in areas where educational (student) interest was insufficient to support departments. At the same time, by splitting research and teaching personnel, these institutes removed undergraduates from their concern entirely, and were partially divorced from the departmental structures under which graduate students entered the university. So, while research institutes may be excellent places for creating knowledge, they are likely to result in relatively low rates of diffusion of this knowledge, particularly into settings where it might be applicable.

Both the tendency of research and teaching to differentiate and the tendency for faculty members to prefer research to teaching are consequences of the operation of the structure of science. Given the unchecked operation of these structures in Canada, similar effects to those observed in the U.S. should be expected in Ontario. Again, the operation of these effects is probably magnified by the specific characteristics of the funding system.

(2) Research and Undergraduate Teaching in Ontario Universities

The required re-allocation of vertical, student-related income to support horizontally obtained research money has already been analysed.

It seems apparent that under a financing system such as Ontario's, research <u>must</u> affect teaching. Instructional costs form a major part of the budget of a university. In Ontario in 1969-70 "Total Academic Expenditures" accounted for between 50 and 60 per cent of universities' operating expenditures, and academic staff salaries ranged from approximately 30-40 per cent (see Table V.1 above). Subsidy for support of research does not occur here as a direct money subsidy, but in large part as a transfer of faculty time. Thus any effect of research on teaching tends not to show up in overall student staff ratios. Rather there is an internal university effect which is much more complex than this.

Faculty members' preferences for allocating their time tend to be research, graduate teaching, and undergraduate teaching in that order. Research is career related; graduate education is usually fairly closely related to a faculty member's major research interests; undergraduate teaching, more often than not, has very little to do with

either of these. It is evident from the above analysis of research funds that research money is not distributed in an egalitarian way within the university. Scientists receive most money, then social scientists, while humanists get little or no research money at all. (Where academics in humanities do receive money in support of research, it is often in the form of a leave fellowship, a kind of support which does not require university subsidy.) Since universities compete for prestige one with another, and since prestige is largely measured by research production, there is a strong tendency in universities to allocate to research-intensive areas any subsidy, direct or indirect, necessary to sustain these. Thus it is possible to identify general orientations at both the university and departmental levels that result in emphasis on the non-undergraduate research areas of the university.

Measuring the effects of this situation is difficult. Ideally, estimates of faculty time spent in the different areas of activity are required. These are not available.

Existing data concerning faculty/student ratios are unsatisfactory for a number of reasons.[18] First, there is the problem of accounting into the ratios graduate

students whose education, even without faculty preferences in this area, takes up more time. Variations in numbers of graduate students, and the fact that graduate students and research income are related, make inter-university comparisons difficult. Second, there is the problem of estimating the use of auxilliary personnel. University-wide faculty/student ratios often hide the fact that much undergraduate teaching is done by auxilliary personnel (teaching assistants, demonstrators, etc.). In published data from the Department of University Affairs, teaching assistants are calculated into the number of "full time equivalent staff" by dividing their salaries by the mean salary for the university.[19] This calculation makes little sense. At prevailing faculty salaries between eight and ten teaching assistants are equal to one professor. The same calculation performed for full status faculty whose salaries are below the mean would reduce their numbers too, while some full professors would count for two assistants. Third, it is to be noted that faculty/student ratios at the university level say nothing about numbers of courses offered. A "squeeze" on undergraduate teaching can mean simply the offering of fewer courses with larger enrolments. Finally, and in line with the analysis in the last paragraph (research income is not evenly distributed across departments) the subsidy of research through faculty time creates a differen-

tial "squeeze" on departments. Enrolments may be allowed to rise in low research-money disciplines without increases in faculty, whereas disciplines with large amounts of research money will be permitted to increase faculty numbers if enrolments rise. Thus most students will be taught in large courses and teaching economies created this way, leaving some faculty effectively in non-teaching positions.

The above arguments suggest that some or all of the following should be characteristic of research-intensive universities as the mechanism by which research is perpetuated:

(i) a smaller number of course offerings per student, particularly per undergraduate student;

(ii) larger course enrolments and particularly larger course enrolments at lower levels;

(iii) a greater discrepancy in course sizes between departments within the university, with lowest course sizes in the departments with highest research incomes.

Again, substantiation of this analysis for all universities is beyond the scope of this project, although the task would be feasible in a sufficient time period since universities routinely collect most of the data involved. Nevertheless, data are available for the Faculty of Arts and Science at the University of Toronto, covering

a single year, and referring only to undergraduate enrolments. See Table V.3 below, which may be summarized as follows:

(a) The four departments with the highest research income per faculty member have low course loads per faculty member. Only French and German are lower. In addition course enrolments per faculty member in these areas are also low.

(b) Psychology is the highest ranked social science department in terms of research income. Psychology also has the second highest number of enrolments per faculty member. Course loads in psychology are moderate, however, ranking just above the mean.

(c) Most non-college based non-science departments (e.g. history, geography, political economy, anthropology, sociology) have moderate research-per-faculty figures, high course enrolments per faculty member, and high course loads. Exceptions to this are "esoteric" areas, primarily the regional studies programs which have low student enrolment per faculty member.

(d) College based departments (see Note (a), Table V.3) have low research income, but also low enrolment per faculty member. Course loads in these departments vary considerably.

Table V.3

University of Toronto, Faculty of Arts and Science, Research Income per Faculty Member[a], Undergraduate Enrolments per Faculty Member, Undergraduate Courses per Faculty Member, 1968-69.

Department	Research Income per faculty member	Undergraduate Enrolment per faculty member	Undergraduat Courses per faculty mem
1. Zoology	$ 30,433	41	.9
2. Physics	27,958	38	.8
3. Astronomy	20,444	37	.8
4. Chemistry	16,238	54	1.1
5. Psychology	16,018	151	1.5
6. Geology	14,236	18	1.2
7. Botany	10,893	47	1.3
8. Anthropology	9,094	114	1.8
9. Mathematics	5,367	59	1.3
10. Sociology	2,896	162	2.5
11. Geography	2,490	78	1.7
12. Near Eastern Studies	1,691	25	2.5
13. Slavic Studies	1,200	22	1.7
14. East Asian Studies	1,084	22	2.1
15. French	805	52	.4
16. Italian and Hispanic Studies	522	70	2.2
17. Classics	358	46	1.7
18. History	344	80	1.5
19. Islamic Studies	157	8	1.3
20. Fine Arts	93	37	2.2
21. Political Economy	80	99	1.2
22. English	12	60	.4
23. Philosophy	-	32	1.1

Note (a): Numbers of faculty are for "full time equivalents" for all departments except Classics, English, French, German, Near Eastern Studies, Philosophy and Religious Studies. These departments are college rather than university departments, and for these numbers of faculty members were estimated using the Faculty of Arts and Science calendar for 1968-69. Since this procedure probably overestimates full time equivalent faculty members, figures in the table for these departments will be slightly underestimated.

Source: Data supplied by University of Toronto.

A simple, single-variable explanation is insufficient to explain this pattern. Three factors are operating to create differences in teaching situations in departments. These are: first, the effect of research; second, seemingly conscious decisions on the part of U. of T. to sustain relatively esoteric areas which are neither research intensive, nor of particular interest to students; third, Toronto's dual principle of internal organization. Departmental organization at the University of Toronto is part university based and part college based--humanities are organized, for the most part, with their members appointed to colleges. Social scientists and scientists hold university appointments.

Decisions made by the university to sustain low research-income, esoteric areas are seen in the departments of East Asian, Islamic and Slavic Studies. These are all areas of low student demand. The dual principle of university organization results in favourable teaching situations in most of the humanities, despite the fact that these areas have large absolute enrolments. Since the colleges receive a formula allotment from the province, and retain this income, and since they are long-established, relatively powerful segments of the university, colleges can resist the tendency to squeeze their departments, the low-research income humanities. Thus the pressure at U. of T. is on the remaining non-college based, low research income departments--primarily

the social sciences and history. This pattern would not be expected to prevail at universities not possessing this dual organization; in other institutions probably <u>both</u> humanities <u>and</u> social sciences experience the problems outlined above.

Although the above data are for a single faculty at a single university, two speculations about additional information which would have bearing on the general problem have been made. First, there is some suggestion that there is a tendency to allocate more money to research intensive divisions of Ontario universities (e.g. faculties of engineering, medicine, or pure and applied science) than these faculties generate under formula financing. Second, the opinion has been voiced that within medical faculties, there is a similar tendency to allocate the least favourable teaching situations to areas of low research intensity, and thereby subsidize research by "squeezing" teaching.

If the present analyses are correct, a further interesting line of argument follows. The policies adopted by the research intense universities over the past decade have been possible only because the most rapid expansion in enrolments has been in areas where the research level has been low (humanities and social science). Had this not been the case, the funding system would have been a variant of the "prisoners' dilemma."

If expansion had been occurring in high research income areas of universities (i.e. had the expansion been in

physical science, <u>or</u> had the social sciences and humanities been research intensive) increasing student enrolment, and consequent increases in student demands would have cut into faculty research time. This would have created faculty demands for the hiring of additional personnel. Additional personnel would, however, have increased research income since this is largely a function of the number of faculty in a research intensive area. Thus increasing student enrolments would have directly increased research and hence university costs.

Research expansion under the funding system was made possible only by the coincidence of the main increase in undergraduate enrolment with areas which were not research intensive. Increasing the number of faculty members in humanities and social science did not increase the research income of the university at the same rate as increases in physical science personnel. Furthermore, given the low level of research activity, faculty members in these areas were less likely to complain if their staff/student ratios were unfavourable, while heavy teaching demands, in turn, precluded the development of strong research traditions in the areas in which research was initially weak.

This line of argument relates directly to the analysis of faculty supply and demand pursued earlier. Graduate education in Canada has remained relatively weak in areas

in which it was initially weak prior to expansion. Not only is quantity of Ph.D.'s produced an index of this, but the less easily measured indicator, quality, also often suggests the same analysis. The weakness of graduate training in high expansion areas is not only a consequence of the unfavourable conditions for faculty supply that have existed over the past decade; the problem is complicated by the fact that in graduate training institutions the weakest areas of graduate training are also most overburdened with undergraduate teaching.

(3) Speculations on the Consequences of the Organization of Teaching

If the above analysis holds for universities other than Toronto, it would appear that as a consequence of strains engendered by research, a large proportion of enrolments in a university have been and will continue to be in excessively large courses where reliance on low-qualified auxilliary teaching personnel is high. Most of these enrolments, too, will be in the areas of social science and humanities. It is worth noting that these are areas where choice of courses is primarily explained by "intrinsic" interest, and not by the need for certification in an occupation-related skill. Bachelor's degrees in humanities and social sciences do not visibly lead anywhere.

Students in these areas are therefore much less prepared to accept large enrolments. Students in engineering tend to view courses as a process of information transfer which is required to move forward in a career. "Information transfer" is not necessarily required to be interesting and is accomplished just as well when one person talks to 300 as to 50. Humanities and social science students do not have extrinsic orientations. A major source of their motivation tends to derive from the material covered, the quality of lectures, and the interest they perceive being taken in them by the person teaching the course. In large courses "individualization" of instruction becomes impossible, and the propensity for students to experience courses as anonymous, boring and frustrating is consequently increased.

It is thus not difficult to see in growing student activism a strong theme of reasonable discontent with a system of university operation which places large numbers of students in front of faculty members whose ability to lecture has never been seriously taken into account in their employment, and whose existing abilities are severely hampered by the limitations of their teaching situations.

D. <u>Decentralization, Research Institutes, and Some Unintended Consequences for Graduate Education</u>

Focus has been made above on the effects of research on undergraduate teaching. Certain features of current funding may in time also act against graduate education.

Comments have been made elsewhere on the desirability of breaking down disciplinary barriers, particularly in certain areas of applied research. The Institutes appear to achieve this most effectively. There are indications that a number of enterprising ventures of this nature, many of them supported by NRC's Negotiated Development Grants are under way. This exactly follows the American Pattern where research institutes tend to differentiate in areas which are of concern to funding agencies, but where undergraduate interest is insufficient to support departments.

While these institutes offer exciting research possibilities their organization outside the structure of the departments to which students are affiliated, and their heavy research orientation, tend to mitigate against the transmission of knowledge to students. The possibilities for graduate student involvement are usually considerably more than for undergraduates, but there is usually little other than their ties to particular faculty members to

ensure even graduate student involvement.

Any tendency in this direction, while increasing the efficiency of knowledge production, is thus likely to decrease the diffusion and acceptance of ideas. This problem is most serious with graduate students who are more likely to convey ideas into applied work settings and be innovative in using them. At the same time, the broader diffusion of new ideas even at very elementary levels is important because it can create conditions favourable to the importation of innovators. Thus, while specialized research settings have advantages, they also possess disadvantages which centre on the de-emphasis of teaching.

Notes - Chapter Five

1. See Joseph Ben David, The Scientist's Role in Society (Englewood Cliffs, N.J., Prentice Hall, Inc., 1971), 130-133.
2. For a summary of this debate during its most intense stage, see Charles V. Kidd, American Universities and Federal Research (Cambridge, Mass., The Belknap Press of Harvard University Press, 1959), ch. 5.
3. National Science Foundation, Federal Support of Universities and Colleges: Fiscal Year 1968 (Washington, U.S. Government Printing Office, 1968), 23.
4. A Statement to the Committee on University Affairs by the University of Toronto (Toronto, University of Toronto 1970), 138.
5. An Exploratory Cost Analysis of Some Canadian Universities (Ottawa, Association of Universities and Colleges of Canada), 1970.
6. Ibid., iv-v.
7. Walter Hettich, Expenditures, Output and Productivity in Canadian University Education Economic Council of Canada Special Study No. 14 (Ottawa, Information Canada, 1971).
8. Ibid., 20-21.

9. Conversation with Dean MacKintosh, Queen's University.
10. Systems Research Group, Cost and Benefit Study of Post-Secondary Education in Ontario a report prepared for the Commission on Post-Secondary Education, 1970, 112.
11. Great Lakes Institute, Financial Statement 1970 (Toronto, Great Lakes Institute, University of Toronto, 1971).
12. National Research Council: Special Announcement: Operating Grants and Computing Costs 1971.
13. Lee A. DuBridge, "Research and Academic Policy," in Stephen Strickland, Sponsored Research in American Universities and Colleges (Washington D.C., American Council on Education), 8 and 16.
14. Alvin M. Weinberg, Reflections on Big Science (Op. cit.), 155.
15. Ibid; 161.
16. Frederick Betz et al., "Funds, Fragmentation, and the Separations of Functions in the State University," Social Science Information 8, No. 1, 142; and Carlos E. Kruytbosch and Sheldon L. Messinger, "Unequal Peers: The Situation of Researchers at Berkeley," ch. 12 in Kruytbosch and Messinger (eds.) The State of the University (Beverly Hills, California, Sage Publications, 1968).

17. Robert Dubin and Frederic Beisse, "The Assistant: Academic Subaltern," ch. 13 in Kruytbosch and Messinger (*Op. cit.*)

18. See *Report of the Minister of University Affairs of Ontario 1969-70* (Toronto, Department of University Affairs, 1970), Table 21, 95.

19. *Ibid.*, 95, footnote 1.

VI. A Note on Hierarchy

A. Introduction

Before concluding this report and before considering the feasible direction of change for the organization of research in Ontario universities, it is important to consider the implications of the distribution of knowledge production between these universities. The imitation of U.S. structures in Canadian higher education has created a number of anomalous features in these patterns.

B. Higher Education and the Operation of Hierarchy in The U.S.

The important base of comparison between Canada and the U.S. is the absolute, not the relative size of higher education. There are a number of general areas in which absolute size is relevant: all of these have to do with various aspects of the operation of hierarchy. This operation is most marked in the related areas of research, graduate education, and faculty recruitment in the U.S.

Briefly this situation can be described as follows. A small number of institutions in the U.S. dominate the production of knowledge and the training of knowledge producers. These universities draw disproportionate amounts of the total research income of all universities and dominate Ph.D. production both quantitatively and qualitatively. Since the support and training of graduate students

is closely tied to the research function the association of these two features is to be expected.

In certain respects, the rest of higher education in the U.S. acts as a support system for these few prestigious universities. The best undergraduates are funnelled upwards toward the prestigious graduate schools. Some of this funnelling is done through the selection of undergraduates (some undergraduate institutions are better than others and the best graduate schools tend to select from these) and some is done at the end of the undergraduate career (the best undergraduates go to graduate school). This process of inflow to graduate school is reversed in the process of outflow which marks the recruitment of faculty members. At the end of graduate school, the best graduate students are recruited into the most prestigious universities as junior faculty, others not so highly evaluated go to second level institutions. In addition, the leading universities have rigorously applied "up or out" rules which select junior faculty in an extremely competitive process, and once again push out the losers to the second level institutions. Finally, there is another outflow of senior, well-known men who, when their research careers have "peaked," are encouraged to move to the second level institutions, often as chairmen. This is one of the

mechanisms by which second level institutions attempt to raise their prestige by adding "big names" to their faculties.

Much of this dual flow takes place via extended networks of personal contacts. The outflow of graduate students and junior faculty from the high prestige universities means that senior faculty members in these places develop over time an enormous number of contacts throughout the system. These contacts are used in both the recruitment of graduate students whose referees are likely to be known, and the placement of graduate students and out-moving faculty members. Thus personal contacts of well-known figures in disciplines play an important role in the allocation of personnel.

The allied research enterprises of these universities are involved in this process. Once within the inner circle, the receipt of research money is a self-perpetuating process. High prestige draws the best in faculty, and this is likely to be supplemented by aggressive recruitment. The best faculty tend to be more successful in the competition for research money; they are assisted in this by superior facilities, a superiority maintained by the very research money they draw.

C. Hierarchy: Canada and Ontario

The peculiar feature of Canadian higher education in comparison with that of the U.S. is that while hierarchy is in certain respects more pronounced, the working of hierarchy in the academic market place appears to be less pronounced.

Both the receipt of research income and the production of Ph.D.'s are highly centralized in Canada. Thus, the MacDonald Report noted that in 1965-66, "Five universities received over 50 per cent of total funds. Ten universities received 82 per cent of total funds...15 (one third of all universities) received no research income."[1] While data on total research income were not available for the U.S., information is available on receipt of federal government research funds. Thus, while the available data for Canada and the U.S. are not strictly comparable, some indication is apparent of the magnitude of the differences.

In the U.S. in the fiscal year 1968, the 100 universities which received the largest amounts of federal money obtained 80 per cent of total federal money for academic science.[2] Thus the same percentage of research income in the U.S. was received by ten times as many institutions. Similarly, in 1967-68 the University of Toronto, (with the largest research income in Canada) received an estimated 14 per cent of total

research support for Canadian universities. Massachusetts Institute of Technology, the top receiver of research income in the U.S. received approximately six times as much money from the U.S. federal government alone as Toronto did from all sources. But, at the same time, M.I.T.'s share of total federal U.S. research funds was under 3 per cent.[3] Thus, while the absolute amount of the University of Toronto's research income was much smaller than that of M.I.T., Toronto's share was larger relative to other Canadian universities than was M.I.T.'s relative to other universities in the U.S.

A similar situation prevails in relation to Ph.D. production. In 1968-69 Toronto produced 18 per cent of Canada's Ph.D.'s.[4] Between 1963 and 1966 M.I.T. produced just over 3 per cent of the Ph.D.'s in the U.S.[5]

If percentages of universities producing percentages of Ph.D.'s were calculated, the picture in Canada would look much more similar to that in the U.S. But this would be misleading: the smaller absolute size of Canadian higher education means the possibility exists for the dominance of a single institution.

Comprehensive data indicating place of degree for Ontario faculty members are not available. The one relevant piece of information is contained in Ring of Iron. This

study reports the origins of faculty degrees in engineering for Ontario university engineering staff as follows:

University of Toronto - 21 per cent
Other Canadian university - 22 per cent
United States - 26 per cent
United Kingdom - 23 per cent
Other - 8 per cent[6]

This is offered as "a possible reason for the sameness of Ontario engineering schools."[7]

In the U.S. the larger number of "top" institutions keeps competition between "centres of excellence" high, but these mechanisms are clearly less pronounced in Canada. The most serious risk here is that U. of T. comes to dominate informal recruitment networks of the type described above.

While arguments for concentration can be made in terms of the advantages of economies of scale in research, and in terms of the desirability of some "centres of excellence," over-concentration produces a number of disadvantages that have to do with recruitment patterns. If a single university came to dominate both research and Ph.D. production, inevitably a substantial proportion of the Ph.D.'s in all universities in the system would come to be drawn from this institution. This would mean that competition between universities would be severely reduced. Nor could the long run excellence of all departments in the dominant institution be guaranteed. In addition, the in-breeding which would

occur as the top institution was forced to recruit primarily from amongst its own Ph.D.'s, would severely curtail the innovative stimulus that comes from introduction of faculty trained elsewhere.

The risk of a single dominating institution declining from "in-breeding" is high. This problem is exacerbated by the fact that the "network" recruitment ties described above tend to operate in partial independence of excellence and thus can act to spread the decline at the top throughout the system.

This has been precluded so far by a rate of expansion so high that faculty had to be "imported" from outside Canada. Nevertheless, the University of Toronto's network ties must already be considerable, and if foreign competition is excluded as internal supply becomes more satisfactory, these ties would become yet stronger and more effective.

These issues involve a dilemma for policy making. On one hand, the necessity for restricting spending on higher education might lead to the conclusion that Ontario can only support a small number of "centres of excellence." This argument could be taken to imply that "economies of scale" dictate one or two large, high-prestige institutions in which research and graduate education would be concentrated

while other Ontario universities assume a secondary role. On the other hand, while large size may be conducive to research, it has disadvantages for the system as a whole. Large scale institutions of this type might, within a university system which is relatively small both at the local and national level, lead to the disadvantages of the recruitment patterns described above. In re-designing higher education in Ontario, specific care must be taken to avoid increasing the domination of both Ontario, and Canadian universities generally, by the University of Toronto.

<u>Notes - Chapter Six</u>

1. *The Role of the Federal Government in Support of Research in Canadian Universities*, Science Council of Canada, Special Study No. 7 (Ottawa, Queen's Printer, 1969), Table 3.3., note a., 46.
2. National Science Foundation, *Federal Support to Universities and Colleges Fiscal Year 1968* (Washington, U.S. Government Printing Office, 1968), Table 13, 23.
3. *Ibid.*, 23.
4. DBS- 81 - 211 (1968-9).
5. NSF, *Federal Support*, Table 15, 27.
6. *Ring of Iron* (*Op. cit.*), 29.
7. *Ibid.*, 29.

VII. Overview: The Possible Directions of Change

The orientations of those who set policy relative to universities are often fundamentally different from the orientations of the people who staff universities. A major thrust of policy making relative to higher education in Canada, the United States, and Great Britain has been the "democratization" of access to universities. This suggests that for legislators the import of students in universities is much greater than the significance of knowledge production which is often the primary interest of academics.

Given this, academics are often placed in the peculiar position of arguing both that the research they do should not be evaluated according to its usefulness (that is, universities should be the loci of basic research) and that basic research is ultimately useful (all applied knowledge was once basic knowledge and therefore basic knowledge is essential to application). The success of academics in arguing for the basic research orientation of universities has been in part due to the impossibility of logically proving the latter argument incorrect. Some of what was once basic research is now applied, but any applications for current basic research are in the future and therefore impossible to gauge. All this is further obscured by the popular mystique which surrounds science.

It is undoubtedly true that some of the preoccupations of contemporary physics are no less esoteric than those of classics and not one bit more practical. Precisely how much abstruseness prevails is not clear. In popular thinking, however, "science" is undoubtedly much more useful than it actually is.

Ben David has recently suggested that there is very little justification in economic terms for the tendency of academic research to be "basic knowledge" oriented. He argues:

> ...until recently there has been a very poor relationship between the place and time of the production of basic scientific ideas on the one hand, and the reaping of technological and economic benefits from it on the other. In fact, one possible way of interpreting the evidence would be that, from the point of view of the expectation of economic returns, fundamental research is a bad and unjustifiable investment for any given country since the possibility that its results can be turned into useful technological applications is unpredictable, and it is particularly difficult to predict whether the applications will benefit the economy of the same country or those of its competitors. (Had international trade been as free as scientific communication is, this would, of course, not matter.)
>
> From such an interpretation, it would follow that, provided economic gain were the only consideration, the best policy for each country would be to reduce its expenditure on basic research to the minimum necessary for the training of people capable of 'parasitizing' the results of research done elsewhere.[1]

Ben David makes another comment germane to Canada: "The separation of the scientific from the technological and business communities explains the absence of direct links between fundamental and applied research."[2]

A decision concerning the desirability of increasing the "usefulness" of university research is not only beyond the scope of this project, but also beyond the bounds of social science. However, it does seem likely that in a continuing tight money situation university research will increasingly be evaluated according to criteria of usefulness. "Usefulness" appears directly to imply research of a more applied nature. This in turn means either research in areas of industrial relevance, or perhaps equally important, research in areas where the federal and provincial governments are likely to face increasingly urgent "problems."

It is clear that basic research is exceedingly difficult to justify in terms of local, Ontario needs. If as Ben David suggests, it is difficult to justify basic research according to criteria of usefulness at a national level, then local justifications are even more problematic. Clearly, then, decisions about the support of basic research must be made at a national level and national financing must be involved.

Hopefully decisions in this area will come to be taken as part of a more coherent Canadian science policy than has hitherto existed.

Second, if basic research should be the concern of the federal government, the performance of applied research is much more reasonably a matter of provincial concern. Furthermore, while it is possible to suggest a division of concern, this does not imply that these efforts should be isolated from one another. So long as money for basic research is available, academics will choose this area. Unless changes at the provincial level to increase applied research are accompanied by changes at the federal level which reduce the amount of basic research in universities, attempts to encourage applied research are likely to fail. A coherent national science policy offers the possibility of co-ordinating these national and local efforts.

The perceived interests of academics lie elsewhere than in applied research. A position is assumed below that directly challenges this: it is considered that universities should move in the direction of increased usefulness. Plausibly, this suggests not only a movement toward increased applicability of scientific research, though this is the main focus of concern here, but also movement of universities into areas of social criticism and action.

As far as the area of scientific research is concerned, however, use of this assumption makes it possible to suggest some guidelines for change that have other desirable features relative to teaching and university finances generally.

The first important step in changing the orientation of some university research would be to change the current funding system. Directly attempting to influence academics by any other means than restructuring funding would undoubtedly create large amounts of resistance to what would be regarded as a "threat" to "academic freedom." Thus, any reduction would have to be accomplished via a change in the funding procedures of the federal agencies. An interesting strategy is available here.

The current direct federal funding of basic research effectively pays for approximately half the cost of that research. Costs not included in grants are covered by the indirect reallocation of university money described in Chapter V above. If federal agencies were to take on the full cost of research by gradually increasing the proportion of overhead and direct costs that they allowed without increasing the total amount of money allocated to universities (over, say, a three year period), this would effectively halve the amount of basic research. If full

costs had to be covered, fewer projects could be funded out of the same amount of money. In addition, the working of "peer assessment" and the general organization of the Councils would remain unchanged. A halving of the amount of basic research could thus be achieved with a minimum of change in current funding structures.

This change would have the effect of creating specialist researchers in universities. Since part of researchers' salaries would be paid from research grants, some faculty members would have lower involvement in teaching, particularly undergraduate teaching. At the same time other faculty members would be unable to obtain funds for basic research. Those unable to obtain such funds would probably be concentrated in the lower research-intensive universities.

If these changes at the federal level were accompanied by a provincial program oriented to encouraging "useful" research, some of the researchers unable to obtain basic research funds would turn their attention to applied research. Ideally such a program should include not only financial support for applied research, but also attempts to increase communication between universities on the one hand and industry and government on the other. The National Research Council's industrial fellowships might be a model for a similar Ontario program, and could operate both for faculty and graduate students. Similarly

there is the possibility of a program of provincial Negotiated Development Grants similar to those provided by NRC, except that the provincial program could have a greater applied emphasis. There are also interesting possibilities in the area of partial provincial government subsidies for industrially financed university research. Certainly existing programs--those of NRC mentioned above, and such experiments as McMaster's Centre for Applied Research in Engineering Design--deserve careful study. A concerted attempt to strengthen the research base of Canadian economic and industrial effort is clearly indicated by the weakness of this area, not only in comparison with the U.S., but also in comparison with U.S. firms in Canada.

These changes in research funding and organization would not necessarily require an increase in money allocations to education. Reductions in the amount of basic research could be achieved by the means outlined above without change in the overall amount of Council money received for university research. With the cost of basic research completely covered by grants, the necessity for internal university reallocation of vertical income to research would be removed. Thus the portion of university income now used in this way

would be freed for reallocation, some to the new areas of applied research and some to resolve university teaching problems.

This latter is another important consequence of the change in funding policy and strategy outlined above. In Chapter V it was suggested that current funding policies together with university concern for prestige and the preferences of academics for research act in conjunction to create a "squeeze" on teaching in the non-research-intensive areas of high student demand. Reductions in the amount of money available for basic research would leave some researchers unable to pursue what tends to be their first-preference activity. Those without basic funds would have a choice of alternate self-images: applied researcher, or teacher. If formal attempts were made to encourage this, universities might begin to take systematic account of teaching performance in promotion and faculty assessment. "Formal" mechanisms for encouraging a re-orientation of academic structures in this direction could include the establishment within the university of prestigious or monetarily rewarding teaching appointments.

Changes of this nature would encourage in-department specialization, and the partial differentiation of the roles of basic researcher, applied researcher, and teacher.

Each could then be evaluated in slightly different ways. Such an innovation would probably be more productive than creating specialized research institutes, since a closer contact would be retained between research and teaching and thereby keep alive important parts of the process of diffusing knowledge.

So far, we have been concerned primarily with the within-university changes that would be worked by specified shifts in funding. It is also important to consider changes which would be worked at the level of the university system as a whole.

One important effect at this level would be a greater concentration of basic research in a smaller number of institutions. The four universities which are now research intensive would probably perform most of the basic research done in Ontario universities, while applied researchers would tend to concentrate in the second level institutions. While this structuring has the advantage of emphasizing "centres of excellence" and over time would tend to concentrate basic research talent, there are also disadvantages. The primary risk would be that basic and applied research institutions differentiate entirely, thus precluding interaction and hindering the important process of diffusing basic knowledge into settings where its

applications can be worked out.

The real risk would be the tendency to regard second level applied institutions as second-rate options. This might be amplified by the fact that the majority of Ph.D.'s are likely to be trained, unless changes are made to prevent this, in the basic-research institutions. Comment has already been made about the extent to which Toronto now dominates the indiginous training of academic manpower and is likely to increase this domination in the future. A pattern of training Ph.D.'s which produced entirely basic-science academics for whom only limited employment in basic-science institutions would be available, definitely would experience serious strains. Not only would the new Ph.D.'s who entered the applied-research universities be dissatisfied, but Ph.D.'s would not be suitable for industrial employment. An important element of the push for university usefulness would thus be lost.

There are two mechanisms available for countering these tendencies, either or both of which could be employed. First, the tendency toward institutional specialization in either basic or applied research could be resisted. The extent to which this is feasible is not clear since a relatively large amount of control over the allocation of research money would be required. For example, it might be necessary to impose a quota on the percentage of

total basic-research funds which could be granted to a given university. This, inevitably, would reduce the level of open competition for research funds and impinge upon the process of assessing research proposals by merit. A second alternative is to attempt to decentralize Ph.D. production so as to ensure the training of adequate numbers of Ph.D.'s with applied orientations. This would ensure adequate academic manpower for both the applied institutions and for industry. Furthermore, it could be achieved very simply at a provincial level by controlling the funds allocated to universities for graduate education.

Concentration of Ph.D. production in a small number of institutions is to be resisted for another reason. In Chapter VI the disadvantages of the dominance of Ph.D. production by a single institution were identified. These ideas also suggest that some decentralization in Ph.D. production is to be encouraged.

While control over Ph.D. production of this type would preclude the spread of basic orientations into applied and industrial settings, it would not preclude the differentiation of the university system into isolated, specialized segments. Preventing this from occurring would require additional changes. If institutional ventures into areas of applied research were to be successful, it is important that the universities involved have sufficient drawing

power to attract excellent personnel. Structures at the level of "Colleges of Technology" which are grafted onto the bottom of higher education's prestige structure tend to remain second rate because they can only attract both second rate teachers and second rate students.

One way to counter these tendencies is to develop mechanisms which encourage the flow of academics between the various levels of institutions. This flow is also important because it increases the interaction between the various levels of knowledge and hence the probability of useful application and innovation. Encouragement of faculty mobility between universities could be achieved via a centrally encouraged program of faculty exchanges.

Increased faculty mobility is important in another way, particularly in any transition period towards a new system. If the ideas suggested by the analysis of university expansion in the earlier sections are correct, many faculty who are now in tenured positions at various places in the system could be encouraged to move to "find their levels." This would ideally involve not only the encouragement of exchanges, but also abolition of tenure, and other steps to encourage a period of mobility. Creation of a single Ontario university system with all appointments being considered appointments to the system rather than to individual universities is one plausible way of increasing

mobility.

The Ontario university system appears well suited to the kind of changes outlined above. There is dispersion of institutions amongst population centres and thus the possibility of various forms of specialization relative to local needs. Proposed changes would in fact encourage what is already some de facto specialization of this kind. The need for increased "interface" between industries and universities in Canada is generally strong, as are the needs to develop expertise relative to problems that will be confronted at provincial and federal government levels. Beyond this, students' responses to universities are likely to be increasingly important so it is essential to develop mechanisms which safeguard and protect the teaching side of universities from the engulfing tendencies of research, and provide education in universities which is perceived by students as relevant to the outside world.

Finally, there are issues of cost. The changes outlined above do not imply major changes in current funding. Were formula financing to be coupled with a research-funding system which covered the full cost of research, complaints about formula financing would lose much of their foundation. "Centres of excellence" would develop competitively rather than through the discriminatory treatment which would be implicit in a system giving favourable funding consideration

to those universities moving toward or now already experiencing financial problems. The changes outlined above are, in the main, actions which redistribute money between categories. Similarly, centrally encouraged exchanges of faculty between universities would be achieved through a similar redistribution of a small amount of money. Increased direction and planning relative to universities could be achieved by resuming central control over a small portion of university finances and restricting the use of some money to specified activities. The money involved here would be that used to support various exchange-fellowship, leave-fellowship and teaching-fellowship programs for both faculty and certain categories of students, and that allocated to applied research. Other features of the existing funding system, specifically the general notion of "formula" financing, could remain substantially intact.

Notes - Chapter Seven

1. Joseph Ben David, *Fundamental Research and the Universities* (Paris, Organization for Economic Co-operation and Development, 1968).

2. *Ibid.*, 59.

Appendix One

Activities of Federal (Non-Council) Agencies and Departments in Support of University Research - Ontario, 1967-68.

UNIVERSITY	AGENCY			
	Dept. of Agriculture	Atlantic Dev't. Board	Atomic Energy of Can. Ltd.	Atomic Energy Control Board
Toronto	$14,880	–	71,525	23,000
McMaster	–	–	12,605	226,000
Western	7,000	–	16,124	–
Queen's	8,000	–	42,522	120,000
Carleton	19,000	–	2,475	–
Ottawa	9,900	–	20,200	81,000
Guelph	127,325	–	5,808	–
Windsor	–	–	20,800	–
Waterloo	–	–	37,025	–
York	–	–	–	–
Waterloo Lutheran	–	–	–	–
Lakehead	–	–	–	–
Trent	–	–	–	–

UNIVERSITY	AGENCY				
	Canada Emergency Measures Org.	Central Mortgage and Housing	Defence Research Board	Economic Council of Canada	Eldorado Mining & Refining Ltd.
Toronto	$11,994	-	391,725	10,040	-
McMaster	33,543	-	143,050	-	-
Western	-	-	130,100	15,000	-
Queen's	-	-	91,250	-	20,000
Carleton	-	124,300	27,200	15,950	-
Ottawa	-	-	56,900	25,068	-
Guelph	-	-	16,050	-	-
Windsor	-	-	43,950	-	-
Waterloo	-	116,025	105,950	-	-
York	-	96,000	26,000	-	-
Waterloo Lutheran	-	-	-	-	-
Lakehead	-	-	-	-	-
Trent	-	-	-	-	-

UNIVERSITY	AGENCY					
	Dept.Energy Mines & Resources	Fisheries Research Board	Dept. Fores-try & Rural Development	Dept.of Indian & Northern Affairs	Canadian Wildlife Service	National & Historic Park Branch
Toronto	49,837	64,660	50,700	21,500	19,900	1,500
McMaster	22,200	-	5,405	-	6,100	-
Western	17,460	-	-	-	12,000	-
Queen's	31,510	-	14,800	-	-	-
Carleton	13,480	5,000	-	-	3,855	-
Ottawa	8,280	3,500	-	8,000	5,200	3,160
Guelph	14,400	6,500	10,996	-	38,075	-
Windsor	-	-	-	-	-	-
Waterloo	64,200	-	5,000	4,900	-	1,500
York	1,000	-	3,200	-	11,145	-
Waterloo Lutheran	3,200	-	-	-	-	-
Lakehead	-	-	-	-	-	-
Trent	-	-	-	-	-	-

UNIVERSITY	AGENCY				
	Dept. of Industry	Dept. of Labour	Dept. of Manpower & Immigration	National Design Council	National Museums of Canada
Toronto	29,900	15,000	35,046	10,128	6,500
McMaster	-	3,650	1,875	-	-
Western	-	1,867	-	-	-
Queen's	17,812	22,000	18,100	-	-
Carleton	-	4,750	3,000	-	-
Ottawa	-	16,088	-	-	1,500
Guelph	-	-	-	-	1,200
Windsor	-	1,800	-	-	-
Waterloo	18,101	-	4,970	10,950	3,200
York	-	3,300	-	-	-
Waterloo Lutheran	-	-	1,500	-	-
Lakehead	-	-	2,980	-	2,500
Trent	-	-	-	-	-

UNIVERSITY	AGENCY			
	Dept. Public Works	Dept. Sec. of State	Solicitor General	Dept. of Transport
Toronto	-	-	-	$13,000
McMaster	-	-	-	-
Western	-	-	-	$32,000
Queen's	$14,000	-	-	$13,000
Carleton	-	$4,500	-	-
Ottawa	-	-	$5,000	-
Guelph	-	-	-	-
Windsor	-	-	-	-
Waterloo	-	-	-	$19,300
York	-	-	-	$5,000
Waterloo Lutheran	-	-	-	-
Lakehead	-	-	-	-
Trent	-	-	-	-

Note: The following agencies also fund research but a breakdown by universities was not available. Amounts funded are for all Canada: Air Canada, $3,900; Bank of Canada, $28,700; CNR, $24,000; Dept. Consumer and Corporate Affairs, $209,220; Dept. of External Affairs, $584,739; Canadian International Development Agency, $1,661,729; Dept. of Finance, $130,000; Dept. of Indian and Northern Affairs (Northern Administration Branch), $1,000; Inter-National Joint Commission, $429; National Harbours Board, $3,000; National Health and Welfare, $7,164; Polymer Corp. Ltd., $58,100; Dept. of Veteran Affairs, $80,747.

Source: <u>The Role of the Federal Government in Support of University Research</u>, Special Study No. 7, Science Council of Canada (Ottawa, Queen's Printer, 1969) Appendix 1, 249-311.

Appendix Two

Negotiated Development Grants Received by Ontario Universities - 1964-65 - 1969-70

			Toronto			
Project	Year 64-65	65-66	66-67	67-68	68-69	69-70
Linear Accelerator	$500,000 50,000	$125,000	$200,000	$320,000	$280,000	$230,000
High Resolution Mass Spectrometer			120,000			
Great Lakes Institute			120,000 35,000	120,000	75,000	85,000
High Energy Physics				177,000	310,000	130,000 180,000
Materials Research				125,000	125,000	75,000
Operation of Van De Graaf Accelerator					32,000	10,000
Institute for Aerospace Studies					40,000	46,000 20,000
Systematic and Evolutionary Zoology						170,000
Computer System Research						90,000
TOTAL	$550,000	$125,000	$467,000	$742,000	$863,000	$1,036,000

				McMaster			
Project	Year 63-64	64-65	65-66	66-67	67-68	68-69	69-70
Van De Graf Tandem Accelerator				$540,000	$ 80,000	$500,000 232,000	$321,000
Materials Research Centre					200,000	200,000	100,000
TOTAL				$540,000	$280,000	$932,000	$421,000

			Western				
Project	Year 63-64	64-65	65-66	66-67	67-68	68-69	69-70
Astronomical Telescope			$25,000	$75,000	$117,000	$133,000	
Design Study of Thomson-Scatter Ionospheric Radar System					20,000		
Photo-Chemistry							35,000
TOTAL			$25,000	$75,000	$137,000	$133,000	$35,000

			Queens			
Project	Year 64-65	65-66	66-67	67-68	68-69	69-70
Long-Base Line Interferometry			$5,000			
Instrumentation for 3-Dimensional Wave Basin				$40,000	$64,000	
Research in Math					100,000	100,000
TOTAL			$5,000	$40,000	$164,000	$100,000

			Waterloo			
Project	Year 64-65	65-66	66-67	67-68	68-69	69-70
Research in Solid Mechanics					$100,000	$200,000
Extractive and Process Metallurgy						161,400
TOTAL					$100,000	$361,400

			Carleton			
Project	Year 64-65	65-66	66-67	67-68	68-69	69-70
Study of Canadian Participation in Accelerator Program					$ 35,000	
High Energy Physics					170,000	190,000
TOTAL					$205,000	$190,000

This information was obtained by searching NRC's Annual Report on Support of University Research for listings in Ontario Universities. Particularly in the early 60's when policy on NGD's was being formulated, large scale support of this type is sometimes listed under "grants-in-aid." For example, the Great Lakes Institute received an "Oceanography and Limnology Operating Grant" of $85,000 in 1964-65, and individual members of the Institute are listed as having received grants-in-aid totalling $215,000 in 1965-66 and 1966-67. Prior to those years other support is listed.

Source: NRC Annual Reports on Support of University Research.

Appendix Three

National Research Council Support of Computer Facilities in Ontario Universities, 1962-63 - 1969-70

University	62/63	63/64	64/65	65/66	66/67	67/68	68/69	69/70
Toronto	50,000* 40,000	50,000* 40,000	106,000*	58,000* 12,900+	185,000* 184,575+	310,650* 108,981+	467,430* 303,390+	2,006,310 157,270+
McMaster		25,000*	48,000*	68,500*	74,200* 961+	133,110* 2.748+	210,360* 3,720+	287,400* 4,000+
Western	18,900*	29,600*	30,000* 9,400+	47,900* 13,400+	53,100*	141,350* 15,250+	132,370* 19,050+	169,380* 34,850+
Waterloo	6,000+	11,000+	52,000*	64,000* 7,200+	94,000* 30,000+	34,800* 107,880+	159,730* 123,045+	229,840* 172,883+
Queen's	12,000*	12,000*			47,100*	97,010*	133,190*	186,750*
Carleton			7,000*	13,000*	44,400* 6,000+	41,140*	56,710*	105,350*
Guelph				17,300*	20,500*	58,070*	74,000*	128,620* 4,000+
Brock					64,000* 2,500+	6,150*	19,250*	25,530*
Windsor			10,000*	14,200*	24,300* 8,500+	28,940*	58,040* 6,026+	80,840*

University	62/63	63/64	64/65	65/66	66/67	67/68	68/69	69/70
York				10,000*	14,900*	37,500*	49,590*	80,400* 7,500+
Trent						3,750*	13,750*	15,000*
Lakehead					3,750*	5,000*	-	29,430*
Ottawa	3,000+	11,000* 3,500+	11,000*	24,000*	39,000*	67,960*	90,615* 6,370+	119,160*
Total *	809,000*	127,600*	264,000*	316,900*	1,272,650*	965,930*	1,465,035*	2,006,310
Total +	49,000+	54,500+	9,400+	33,500+	232,536+	234,859+	356,177+	380,503+

Note: This information was obtained by searching NRC Annual Reports for the individual listings to Ontario universities. There is considerable ambiguity in these reports as to the exact nature of their support. In particular it is difficult to distinguish between support for computer research (software grants) and money for the purchase or rental of equipment (hardware grants). Attempt has, however, been made to judge this from titles. Thus * = hardware, + = software.

Source: NRC <u>Annual Reports on Support of University Research</u>.